Technical Help Guide

Thermal Expansion Valves
Electronic Valves & Controls
Solenoid Valves
System Protectors
Regulators
Oil Controls
Temperature Pressure Controls
Basic Rules of Good Practice
Troubleshooting Guide



2009

Introduction

This Technical Guide from Emerson Climate Technologies provides a detailed explanation on the operation of common refrigeration system components such as thermal expansion valves, solenoid valves, system protectors, regulators, oil controls and temperature pressure controls. Also included in this guide is a listing of the basic rules of good practice and a detailed troubleshooting guide. This guide is designed to fill a need which exists for a concise, elementary text to aid service-men, salesmen, students and others interested in refrigeration and air conditioning. It is intended to cover only the fundamentals of refrigeration and air conditioning theory and practice. Detailed information for specific products is available from manufacturers of complete units and accessories. Used to supplement such literature, and to improve general knowledge of refrigeration and air conditioning, this guide should prove to be very helpful.

Emerson Climate Technologies, a business of Emerson, is the world's leading provider of heating, ventilation, air conditioning and refrigeration solutions for residential, industrial and commercial applications. The group combines best-in-class technology with proven engineering, design, distribution, educational and monitoring services to provide customized, integrated climate-control solutions for customers worldwide. Emerson Climate Technologies' innovative solutions, which include industry-leading brands such as Copeland Scroll® and White-Rodgers®, improve human comfort, safeguard food and protect the environment.

Emerson Climate Technologies - Flow Controls Division is a leading manufacturer of valves, controls and system protectors commonly applied in air conditioning and refrigeration systems worldwide. The company continues to pioneer the control of refrigerant flow through innovative, high performance components, such as thermal expansion valves and filter driers.



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Thermal Expansion Valves



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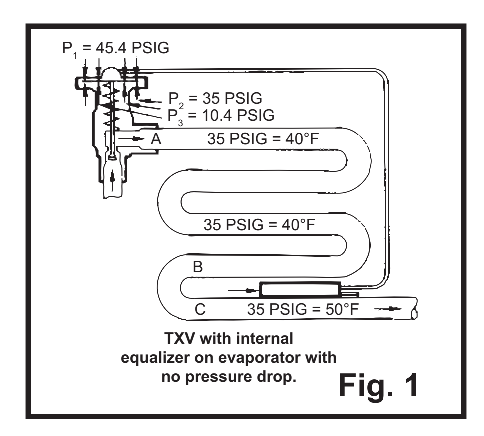
The most commonly used device for controlling the flow of liquid refrigerant into the evaporator is the thermostatic expansion valve (TXV). Also known as thermal expansion valves, TXVs are precision devices designed to regulate refrigerant liquid flow into the evaporator in exact proportion to evaporation of refrigerant liquid in the evaporator.

Refrigerant gas leaving the evaporator can be regulated since the TXV responds to the temperature of the refrigerant gas leaving the evaporator and the pressure in the evaporator. This controlled flow prevents the return of refrigerant liquid to the compressor. The TXV controls the flow of refrigerant by maintaining a pre-determined superheat.

An orifice in the TXV meters the flow into the evaporator. Flow is modulated as required by a needle type plunger and seat, which varies the orifice opening. The needle is controlled by a diaphragm subject to three forces:

1. The power element and remote bulb pressure (P1)
2. The evaporator pressure (P2)
3. The superheat spring equivalent pressure (P3)

These forces are shown in Figure 1.



TXV with internal equalizer on evaporator with no pressure drop. **Fig. 1**

The following sections describe the operation and application of single-outlet TXVs in two general categories: internally equalized and externally equalized.

Internal Equalizer

Three conditions are present in the operation of a TXV:

1. The balanced forces
2. An increase in superheat
3. A decrease in superheat

The remote bulb and power element make up a closed system (power assembly), and in the following discussion, it's assumed that the power assembly is charged with the same refrigerant as that in the system.

The power assembly pressure (P1), which corresponds to the saturation pressure of the refrigerant gas temperature leaving the evaporator, moves the TXV pin in the opening direction.

Opposed to this opening force on the underneath side of the diaphragm and acting in the closing direction are two forces: the force exerted by the evaporator pressure (P2) and that exerted by the superheat spring (P3). In the first condition, the TXV will assume a stable control position when these three forces are in balance (P1 = P2 + P3). See figure 1A.

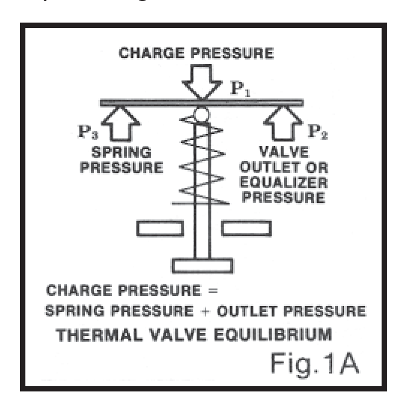


Fig.1A

If the temperature of the refrigerant gas at the evaporator outlet (remote bulb location) rises above the saturation temperature corresponding to the evaporator pressure as it becomes superheated (P1 greater than P2 + P3), the TXV pin moves in an opening direction.

When the temperature of the refrigerant gas leaving the evaporator decreases, the pressure in the remote bulb and power assembly also decreases and the combined evaporator and spring pressure cause the TXV pin to move in a closing direction (P1 less than P2 + P3).

For example, when the evaporator is operating with R-134a at a temperature of 40°F or a pressure of 35 psig and the refrigerant gas leaving the evaporator at the remote bulb location is 45°F a condition of 10°F superheat exists. Since the remote bulb and power assembly are charged with the same refrigerant as that used in the system R-134a, its pressure (P1) will follow its saturation pressure-temperature characteristics. With the liquid in the remote bulb at 45°F, the pressure inside the remote bulb and power assembly will be 40 psig acting in an opening direction. Beneath the diaphragm and acting in a closing direction are the evaporator pressure (P2) of 35 psig and the spring pressure (P3) for a 10°F superheat setting of 5 psig (35 psi + 5 psi = 40 psi) making a total of 40 psig. The TXV is balanced, 40 psig above and 40 psig below the diaphragm.

Changes in load cause the TXV pin to move:

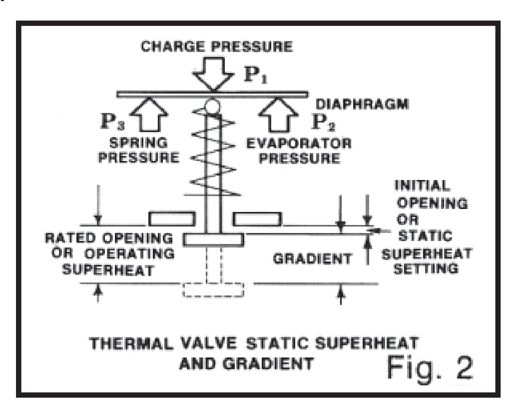
- Increasing the superheat will cause the TXV to open
- Decreasing the superheat will cause the TXV to close

Factory Settings of TXVs

The factory superheat setting of TXVs is made with the TXV pin just starting to move away from the seat. The superheat necessary to get the pin ready to move is called static superheat.

TXVs are designed so that an increase in superheat of refrigerant gas leaving the evaporator is needed for the TXV pin to open to its rated position.

This added superheat is known as gradient. For example, if the factory static is 6°F superheat, the operating superheat at the rated stroke or pin position (full load rating of TXV) will be 10°F to 14°F superheat (See fig. 2).



THERMAL VALVE STATIC SUPERHEAT AND GRADIENT Fig. 2

Manufacturers usually furnish the adjustable type TXV with a factory static superheat setting of 6°F to 10°F unless otherwise specified.

When using non-adjustable TXVs, it's important that they are ordered with the correct factory superheat setting. For manufacturer's production lines it is recommended that an adjustable TXV be used in a pilot model lab test to determine the correct factory superheat setting before ordering the non-adjustable type TXV.

If the operating superheat is raised unnecessarily high, the evaporator capacity decreases, since more of the evaporator surface is required to produce the superheat needed to operate the TXV.

A minimum change of superheat to open the TXV is important because it provides savings in first cost of the evaporator and cost of operation.

The TXV described so far is internally equalized, where the evaporator pressure at the TXV outlet is admitted internally and allowed to exert its force beneath the diaphragm. In the next section the externally equalized TXV will be discussed.

External Equalizer

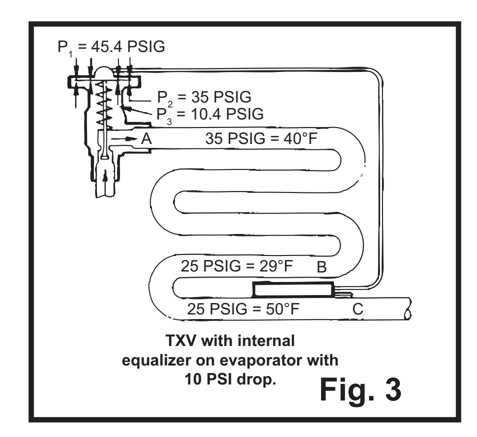
A TXV with an external equalizer is required when the pressure drop through the evaporator is substantial:

- 3°F for residential air conditioning
- 2°F for commercial air conditioning
- 1°F for refrigeration low temperature range

This is because the pressure drop will hold the TXV in a fairly "restricted" position and reduce system capacity. The evaporator should be designed or selected for the operating conditions and the TXV selected and applied accordingly.

For example, an evaporator is fed by a TXV with an internal equalizer, where a sizable pressure drop of 10 psi is present (See fig. 3). The pressure at point "C" is 25 psig or 10 psi lower than at the TXV outlet, point "A", however, the pressure of 35 psig at point "A" is the pressure acting on the lower side of the diaphragm in a closing direction. With the TXV spring set at a compression equivalent to 10°F superheat or a pressure of 10.4 psig, the required pressure above the diaphragm to equalize the forces is (35 + 10.4) or 45.4 psig. This pressure corresponds to a saturation temperature of 50°F. The refrigerant temperature at point "C" must be 50°F if the TXV is to be in equilibrium. Since the pressure at this point is only 25 psig and the corresponding saturation temperature is 28°F, a superheat of (50°F - 29°F) or 21°F is required to open the TXV.

This increase in superheat, from 10°F to 21°F means that more of the evaporator surface needs to be used to produce this higher superheated refrigerant gas. The evaporator surface available for absorption of heat is reduced and the evaporator is starved before the required superheat is reached.

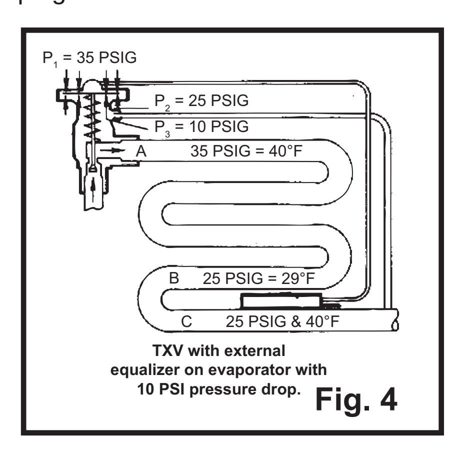


TXV with internal equalizer on evaporator with 10 PSI drop. **Fig. 3**

Since the pressure drop across the evaporator increases with load, the restricting effect becomes worse when the demand on the TXV capacity is greatest.

To compensate for an excessive pressure drop through an evaporator, the TXV must be externally equalized. The equalizer line should be connected to the suction line at the evaporator outlet, past the remote bulb location so that the true evaporator outlet pressure is exerted beneath the TXV diaphragm. The operating pressure on the TXV diaphragm is now free from any effect of the pressure drop through the evaporator, and the TXV will respond to the superheat of the refrigerant gas leaving the evaporator.

When the same conditions of pressure drop exist in a system with an externally equalized TXV (see fig. 4), the same pressure drop still exists through the evaporator, however, the pressure under the diaphragm is now the same as the pressure at the end of the evaporator, point “C”, or 25 psig.

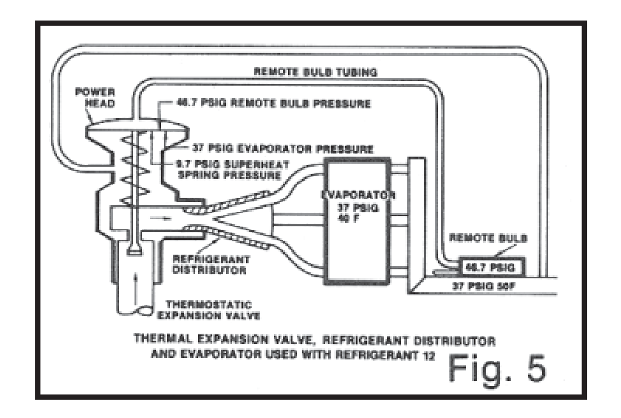


TXV with external equalizer on evaporator with 10 PSI pressure drop. **Fig. 4**

The required pressure above the diaphragm for equilibrium is (25 + 10) or 35 psig. This pressure, 35 psig, corresponds to a saturation temperature of 40°F and the superheat required is now (40°F minus 29°F) 11°F. The external equalizer has lowered superheat from 22°F to 11°F. The capacity of a system having an evaporator with a sizable pressure drop will be increased by a TXV with the external equalizer when compared to an internally equalized TXV.

When the pressure drop through an evaporator is substantial, or when a refrigerant distributor is used at the evaporator inlet, the TXV must have the external equalizer feature for best performance.

An externally equalized TXV is required when a liquid distributor is used. Although a multi-circuit evaporator may not have an excessive pressure drop, the liquid distributor will introduce a pressure drop, because the distributor is installed between the TXV outlet and the evaporator inlet (See fig. 5).



THERMAL EXPANSION VALVE, REFRIGERANT DISTRIBUTOR AND EVAPORATOR USED WITH REFRIGERANT 12 **Fig. 5**

This change from 10°F to 11°F in the operating superheat is caused by the change in the pressure-temperature characteristic of R-134a at the lower suction pressure of 25 psig.

Location of External Equalizer

The external equalizer line must be installed beyond the point of greatest pressure drop. Since it may be difficult to determine this point, it is best to connect the equalizer line to the suction line at the evaporator outlet on the compressor side of the remote bulb location. (See fig. 4 & 5). When the external equalizer is connected to a horizontal line, always make the connection at the top of the line to avoid oil logging in the equalizer line.

On a multi-evaporator system including two or more evaporators each fed by a separate TXV, the external equalizer lines must be installed so that they will be free from the effect of pressure changes in the evaporators fed by other TXVs. At no time should the equalizer lines be joined in a common line to the main suction line.

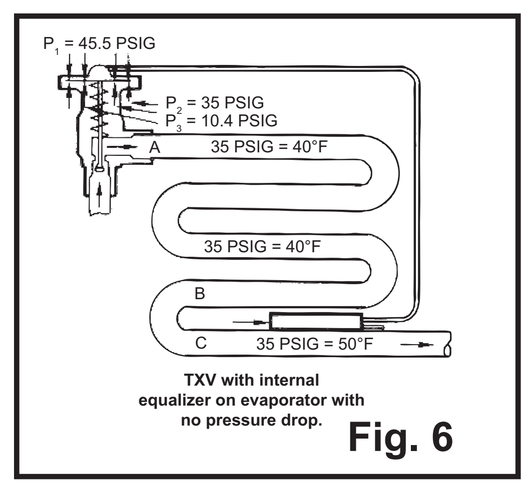
If individual suction lines from the separate evaporator outlets to the common suction line are short, then install the external equalizer lines into the separate evaporator suction headers, or as described in the preceding paragraph.

When the pressure drop through the evaporator is not substantial, install the external equalizer connection at one of the return bends midway through the evaporator. This equalizer location will provide smoother TXV control when used in conjunction with an Evaporator Pressure Regulator. Anytime a control valve is installed in the suction line, the external equalizer line for the TXV must be connected on the evaporator side of the control valve or regulator.

Never cap or plug the external equalizer connection on a TXV, as it will not operate. If the TXV is furnished with an external equalizer feature, the external equalizer line must be connected.

Superheat

A vapor is said to be superheated whenever its temperature is higher than the saturation temperature corresponding to its pressure. The superheat equals the temperature increase above the saturation temperature at that pressure. For example, a refrigeration evaporator is operating with R-134a at 35 psig suction pressure (See fig. 6). The R-134a saturation temperature at 35 psig is 40°F. As long as any liquid exists at this pressure, the refrigerant temperature will remain 40°F as it evaporates or boils off in the evaporator.



TXV with internal equalizer on evaporator with no pressure drop.
Fig. 6

As the refrigerant moves along in the coil, the liquid boils off into a vapor. The liquid is completely evaporated at point B because it has absorbed enough heat to change the refrigerant liquid to a vapor. The refrigerant gas continues along the coil and remains at the same pressure (35 psig); however, its temperature increases due to continued absorption of heat. When the refrigerant gas reaches the end of the evaporator (point "C") its temperature is 50°F. This refrigerant gas is now superheated and the superheat is 10°F. (50°F minus 40°F).

The amount of superheat depends on how much refrigerant is being fed into the evaporator by the TXV and the heat load to which the evaporator is exposed.

Superheat Adjustment

The function of a TXV is to control the superheat of the suction gas leaving the evaporator. If superheat is within reasonable limits, the TXV is operating in a satisfactory way. If superheat cannot be checked directly, it is important to know the size and direction of whatever error is present.

The pressure and temperature of the refrigerant suction gas passing the TXV remote bulb are required for an accurate determination of superheat. When measuring superheat, install a calibrated pressure gauge in a gauge connection at the evaporator outlet. In the absence of a gauge connection, a tee installed in the TXV external equalizer line can be used just as effectively.

A refrigeration type pocket thermometer with appropriate bulb clamp or an electric thermometer with thermocouples may be used to measure gas temperature.

The temperature element from the thermometer should be taped to the suction line at the point of remote bulb location and must be insulated. Thermometers will give an average reading of suction line and ambient if not insulated. Assuming an accurate gauge and thermometer, this method will provide accurate superheat readings.

Approximate Methods of Reading Superheat

When a gauge connection is not available and the TXV is internally equalized there are two ways of estimating superheat. *Neither of these methods will yield an exact superheat reading.*

The first is the two-temperature method, which uses the difference in temperature between the evaporator inlet and outlet as the superheat. The error is caused by the pressure drop in the evaporator. When the pressure drop between the evaporator inlet and outlet is 1 psi or less, the two-temperature method will yield fairly accurate results. But evaporator pressure drop is usually not known and will vary with load. For this reason, the two-temperature method cannot be relied on for absolute superheat readings. The error in this method is negative and always shows a lower superheat.

The second method involves taking the temperature at the evaporator outlet and using the compressor suction pressure as the evaporator saturation pressure. The error is caused by the pressure drop in the suction line between the evaporator outlet and the compressor suction gauge. On packaged equipment and close-coupled installations, the pressure drop and resulting error are usually small. But on large built-up systems or systems with long runs of suction lines, considerable error can result. Since estimates of suction line pressure drop are usually not accurate enough to give a true picture of the superheat, this method cannot be relied on for absolute values. The error in this method is positive and always shows a higher superheat.

The only method for checking superheat that will yield an absolute value involves a pressure and temperature reading at the evaporator outlet.

By realizing the limitations of these approximate methods and the direction of the error, it is often pos-

sible to determine that the cause of the trouble call is because of improper methods of instrumentation rather than any malfunction of the TXV.

When troubleshooting in mountain areas (such as Denver, Colorado or Salt Lake City, Utah) use a Pressure-Temperature chart that has correct readings such as Emerson Climate Technologies' 5,000 ft. pocket chart. Gauge pressures will read lower than they would at sea level.

Filter Driers
Cores
Solenoid Valves & Coils
Regulators
Accumulators

Thermal Expansion Valves
Moisture Indicator
Ball Valves
Oil Controls
Temperature & Pressure Controls



PRESSURE TEMPERATURE CHART HIGH ALTITUDE - 5,000 FT. ABOVE SEA LEVEL

Red (in of Hg) = Vacuum Black (psig) = Vapor **Bold (psig) = Liquid**

°F	R-22	R-134a	R-404A HP-62	R-507 AZ-50	R-408A	R-409A	R-410A
-50	1.2	13.8	2.4	3.3	1.4	13.8	7.3
-48	0.0	13.1	3.1	4.1	2.2	13.1	8.3
-46	0.7	12.4	4.0	5.0	3.0	12.4	9.4
-44	1.5	11.6	4.8	5.9	3.8	11.6	10.6

TXV Selection

Proper TXV size is determined by the BTU/HR or tons load requirement, the pressure drop across the TXV, and the evaporator temperature. Do not assume that the pressure drop across the TXV is equal to the difference between discharge and suction pressures at the compressor. This assumption could lead to incorrect sizing of the TXV.

The pressure at the TXV outlet will be higher than the suction pressure at the compressor because of the frictional losses through the distribution header, evaporator tubes, suction lines, fittings, and hand valves. On rack systems, the EPR valve also adds substantial pressure drop.

The pressure at the TXV inlet will be lower than the discharge pressure at the compressor because of frictional losses created by the length of liquid line, valves and fittings, and vertical lift. The only exception is if the TXV is installed considerably below the receiver and static head built up is more than enough to offset frictional loses. The liquid line should be properly sized for its actual length plus equivalent length due to fitting and hand valves. Vertical lift in the liquid line adds pressure drop and thus static head must be included.

The pressure drop across the TXV will be the difference between the discharge and suction pressures at the compressor less the pressure drops in the liquid line, through the distributor, evaporator, and suction line. ASHRAE tables should be consulted for determining pressure drops in liquid and suction line.

Here is the procedure for properly selecting a TXV:

1. Determine pressure drop across TXV: using the maximum and minimum condensing pressures, subtract the evaporating pressure from each to get the total high-to-low side pressure drop. From these values subtract the other possible pressure losses– piping and heat exchanger losses; pressure drop thru accessories; vertical lift pressure drop; and the pressure drop across the refrigerant distributor.

2. Consider the maximum and minimum liquid temperatures of the refrigerant entering the TXV and select the correction factors for those temperatures from the table below the capacity ratings. Determine the corrected capacity requirement by dividing the maximum evaporator load in tons by the liquid correction factors.

3. Select the TXV size from the proper capacity table for the evaporator temperature, pressure drop available, and corrected capacity requirement.

4. Select the proper thermostatic charge based on the evaporator temperature, refrigerant, and whether a Maximum Operating Pressure (see MOP section) type charge is needed.

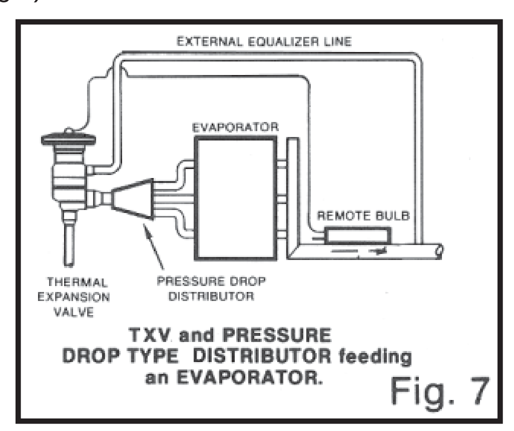
5. Determine connections and whether an externally equalized model is required. Always use an externally equalized TXV when a distributor is used.

A solid column of liquid refrigerant is required for proper TXV operation. Calculate the pressure drop in the liquid line to determine if there will be enough subcooling to prevent flash gas. If the subcooling of the liquid refrigerant from the condenser is not adequate, then a heat exchanger, liquid subcooler, or some other means must be used to get enough subcooling to ensure solid liquid entering the TXV at all times.

Emerson Climate Technologies has prepared extended TXV capacity tables. These tables can be found in the Emerson catalog. Always select a TXV based on operating conditions rather than nominal TXV capacities.

Application Tips

For best evaporator performance, the TXV should be installed as close to the evaporator as possible and in an easily-accessible location for adjustment and servicing. On pressure drop and centrifugal type distributors, apply the TXV as close to the distributor as possible. (See fig.7)



TXV and PRESSURE DROP TYPE DISTRIBUTOR feeding an EVAPORATOR. Fig. 7

Remote Bulb Location

Since evaporator performance depends on good TXV control, and TXVs respond to the temperature change of the refrigerant gas leaving the evaporator, care must be given to types of remote bulbs and their locations. The external remote bulb meets the requirements of most installations. The bulb should be clamped to the suction line near the evaporator outlet on a horizontal run. If more than one TXV is used on adjacent evaporators or evaporator sections, make sure that remote bulb of each TXV is applied to the suction line of the evaporator fed by that TXV.

Clean the suction line thoroughly before clamping the remote bulb in place. When a steel suction line is used, paint the line with aluminum paint to reduce future corrosion and faulty remote bulb contact with the line.

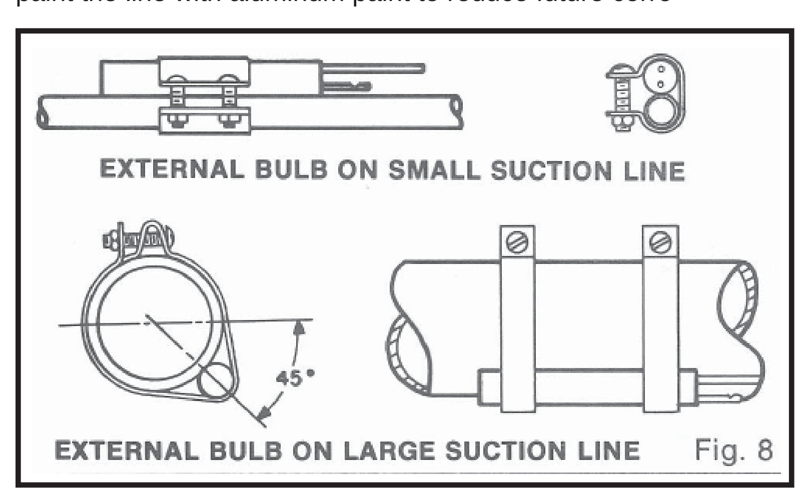


Fig. 8

On lines smaller than 7/8” OD the remote bulb may be installed on top of the line. With 7/8” OD and over, the remote bulb should be installed at the position of about 4 or 8 o’clock. (See fig. 8)

It is good practice to insulate the bulb with a material which will not absorb moisture.

Remote Bulb Well

A remote bulb well will improve the sensitivity of the remote bulb. This occurs with short coupled installations and installations with large suction lines (2-1/8” OD or larger). Remote bulb wells should be used when low superheat is desired or where converted heat from warm rooms can influence the remote bulb. (See fig. 9).

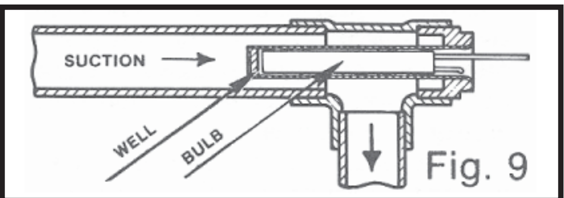


Fig. 9

Never install a remote bulb in a location where the suction line is trapped (See fig. 10). If the liquid refrigerant collects at the point of remote bulb location the TXV operation will be erratic.

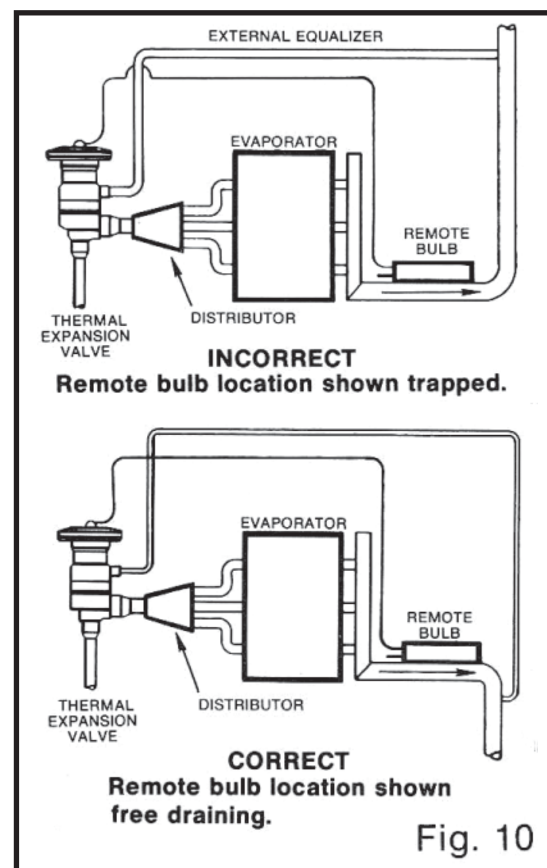


Fig. 10

Large fluctuations in superheat in the suction gas are usually the result of trapped liquid at the remote bulb location. Even on properly designed suction lines, it is sometimes necessary to move the remote bulb a few inches from the original location to improve TXV performance.

On multi-circuit evaporators fed by one TXV, install the remote bulb at a point where the suction gas has had an opportunity to mix in the suction header. Tighten clamps so that the remote bulb makes good contact with the suction line. **NEVER APPLY HEAT NEAR THE REMOTE BULB LOCATION WITHOUT FIRST REMOVING THE REMOTE BULB**.

Hunting

"Hunting" of TXVs is defined as the alternate overfeeding and starving of the refrigerant flow to the evaporator. Hunting is characterized by extreme cyclic changes in the superheat of the refrigerant gas leaving the evaporator and the evaporator or suction pressure.

Hunting is a function of the evaporator design, length and diameter of tubing in each circuit, load per circuit, refrigerant velocity in each circuit, temperature difference (TD) under which the evaporator is operated, arrangements of suction piping and application of the TXV remote bulb. "Hunting" can be reduced or eliminated by the correct rearrangement of the suction piping, relocation of the bulb and use of the recommended remote bulb and power assembly charge for the TXV.

Operation at Reduced Capacity

The conventional TXV is a self-contained direct operated regulator which is inherently susceptible to hunting because of its design and the design of the system to which it is applied.

The ideal flow rate would require a TXV with perfect dynamic balance, capable of instantaneous response to any change in evaporation (anticipation) and with a means of preventing the TXV from over shooting the control point because of inertia (compensation). With these features a TXV would be in phase with the system demand at all times and hunting would not occur.

A conventional TXV does not have built in anticipating or compensating factors. A time lag will exist between demand and response, along with the tendency to over shoot the control point. The conventional TXV may get out of phase with the system and hunt. An example of overshooting occurs when the load increases, causing the superheat of the suction gas to increase. The time interval between the instant the remote bulb senses the increase and causes the TXV pin to move into opening direction allows the superheat of the gas to increase still further.

In response to the rising superheat during the time lags, the TXV has moved further in the opening direction, overshooting the control point and allowing more refrigerant to flow to the evaporator than can be boiled off by load.

When the TXV finally responds to the over-feeding of the evaporator coil, it closes and will tend to again overshoot the control point and remain overly throttled until most of the liquid refrigerant has left the evaporator.

The ensuing time delay before the TXV moves in the opening direction allows superheat of the suction gas to again rise beyond the control point. This cycle, being self-propagating, continues to repeat.

Experience has shown that a TXV is more likely to hunt at low load conditions when the TXV pin is close to the valve seat. This is because of an unbalance between the forces which operate the TXV.

Besides the three main forces that operate the TXV, the pressure difference across the TXV port also acts against the port area and depending on TXV construction, tends to force the TXV either open or closed.

When operating with the pin close to seat, the following will occur:

With the TXV closed, there is liquid pressure on the inlet side of the pin and evaporator pressure on the outlet.

When the TXV starts to open allowing flow to take place, the velocity through the TXV throat will cause a point of lower pressure at the throat, raising the pressure difference across the pin and seat.

This sudden rise in pressure differential while acting on the port area will tend to force the TXV pin back into the seat. When the TXV again opens, the same type of action occurs and the pin bounces off the seat with a rapid frequency. This phenomenon is more frequently encountered with the larger conventional ported TXVs as compared to balance ported TXVs as the force caused by the pressure differential is magnified by the larger port area.

Most TXVs, when properly selected and applied, will overcome these factors and operate with virtually no hunting over a fairly wide load range.

Conventional ported TXVs will perform well to somewhat below 50% of nominal capacity depending on evaporator design, refrigerant piping, size and length of evaporator, and rapid changes in loading.

Nothing will cause a TXV to hunt quicker than unequal feeding of the parallel circuits by a distributor or unequal air loading across the evaporator circuits.

Balanced Port TXV Operation

In conventional TXVs, as the pressure drop across the TXV port changes due to changes in head pressure or suction pressure, the operating superheat of the TXV will vary.

Depending on the operating conditions under which the superheat was originally set, this "unbalance" can sometimes result in compressor flooding or evaporator starvation. A unique design concept called "Balanced Port" cancels the effect of this pressure unbalance, permitting the TXV to operate at a fairly constant superheat over a wide range of operating conditions.

There are 2 fundamental Balanced Port designs:

Double Ported Design (Figure 11a) – In this design, there are 2 paths for the refrigerant to flow. One path creates a force that tends to push the pin in the "open" direction; whereas the other path creates a force pushing the pin in the "closed" position. These paths are designed in such a way that the forces generated in each path are equal to one another, resulting in a "balanced" design.

Single Ported Design (Figure 11b) – In this design, the valve pin has a shoulder added that is on the inlet side of the valve. The high pressure times the area of the shoulder results in an upward (closing) force. The pressure differential across the pin results in a "downward" force. By designing the shoulder carefully, the downward force is negated or "balanced".

Any refrigeration system which experiences changes in operating pressures because of varying ambient, gas defrost, heat reclaim, or swings in evaporator load will benefit from using a balanced port TXV.

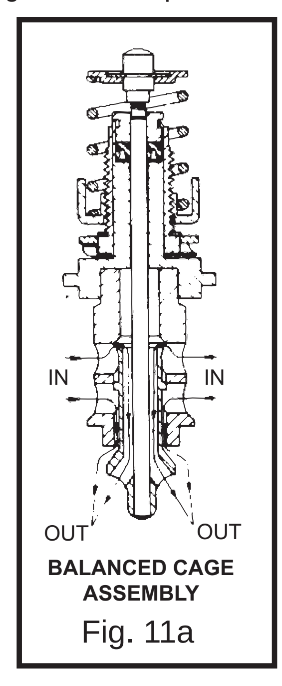


Fig. 11a

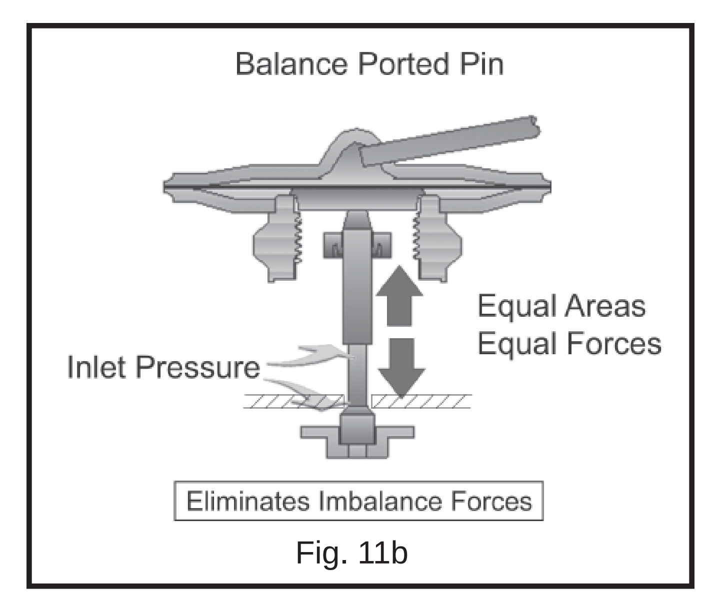


Fig. 11b

M.O.P.

Maximum Operating Pressure (sometimes referred to as Motor Overload Protection) is the ability of a TXV to close down, starve, or shut off if the suction pressure should approach a dangerously high predetermined limit condition. These conditions could overheat a suction cooled compressor or load the crankcase with too dense a vapor pressure. With the TXV in a closed condition the compressor has a chance to pull the suction back down to satisfactory operating conditions. Once below the MOP, the TXV will re-open and feed normally or until there is an overload again.

Power Element Charges

There are several basic types of charges in use today. Most common are the: liquid charge; gas charge; liquid cross-charge; gas cross-charge; and the adsorption charge.

Liquid Charges

The power element contains the *same* refrigerant as the system in which the TXV is used. When manufactured, it is put into the remote bulb in a liquid state. Volume is controlled so that within the design temperature range some liquid always remains in the bulb. Therefore, the power element pressure is always the saturation pressure corresponding to the temperature of the remote bulb.

Liquid charges have the following properties:
- Not subject to cross-ambient control loss
- Little or no superheat at start-up
- Superheat increase at lower evaporator temperatures
- Slow suction pressure pulldown after start-up

REFRIGERANT CODE NAMES

ARI Standard 750-2007 recommends the following color coding of the TXVs:

R-12	White
R-22	Green
R-502	Orchid
R-134a	Light Blue
R-410A	Rose
R-404A	Orange
R-507A	Blue Green (Teal)

Liquid Cross-Charges

Liquid cross-charges means that the power element contains a liquid refrigerant *different* from the system refrigerant in which the TXV is used. The pressure temperature curve of the charge *crosses* the curve of the system refrigerant.

Liquid cross-charge advantages are:
- Moderately slow pull down
- Insensitive to cross-ambient conditions.
- Damped response to suction line temperature changes (reduces tendency for TXV hunting)
- Superheat characteristics can be tailored for special applications

Gas & Gas Cross-Charges

Using a gas charge in place of a liquid alters the operational characteristics, because gas is compressible. At some predetermined temperature, the gas in the remote bulb becomes superheated, limiting the force it exerts. This produces higher superheats at higher evaporator pressures and is labeled the Maximum Operating Pressure (MOP) effect.

The MOP point temperature depends on how that bulb was charged and where it will be used. All gas charges are susceptible to cross-ambient control loss when the power element is colder than the remote bulb. They respond faster, but tend to hunt for the proper operating level, so a ballast is often added to the remote bulb to reduce that tendency.

As in liquid charges, the remote bulb can be filled with the same refrigerant as the system refrigerant (producing a gas charge). Or, it can be filled with a different refrigerant, producing a gas cross-charge.

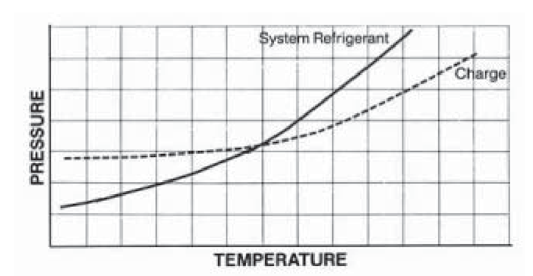
Adsorption Charges

The final type of charge is adsorption. In adsorption, solids hold large quantities of gas, not by taking them into the body of the solid, as in absorption, but by gathering them and holding them on the surface of the solid without chemical reaction.

The vapor penetrates into the cracks and furrows of the solid, allowing far greater capacity than possible with absorption.

The advantage of an adsorption charge is that in a fixed volume, the quantity of vapor adsorbed varies with the temperature and the system. So it can be used to exert operating pressure as a function of temperature.

Typical adsorbents include: charcoal, silica gel, activated alumina.



What happens with an adsorption charge

Which Charge to Use?

Here are some typical examples of applications by refrigerant charge:

Liquid Charge
Ice makers, pilots, liquid injection valves

Liquid Cross-Charges
Commercial refrigeration (low & medium temp.), ice makers, transport refrigeration and air conditioning

Gas Charge
Air conditioning (including mobile), water chillers

Gas Cross-Charge
Heat pumps and air conditioning

MOP
Maximum Operating Pressure

Other TXV Considerations

Solenoid Liquid Stop Valves

The TXV is produced as a tight seating device. But if the TXV is exposed to dirt, moisture, corrosion, and erosion the TXV will not be able to positively shut off. If the remote bulb is installed in a location where during the "off' cycle it is influenced by a higher ambient temperature than the evaporator, the valve will open and admit liquid to the evaporator. Installing a Solenoid Liquid Stop Valve ahead of any TXV is highly recommended.

Filter driers for System Protection

To protect the precision working parts of control valves from dirt and chips which can damage them and make them inoperative, and to protect the entire system from the damaging affects of moisture, sludge and acids, a filter drier should be installed on every system.

Pressure Switch Setting

On TXVs with M.O.P., a Pressure Switch must be set to cut in at a pressure lower than M.O.P. rating of the TXV.

Emerson TXVs

Emerson's TXVs are designed for a wide range of air conditioning, refrigeration, heat pump, and chiller applications. Emerson uses stainless steel power elements that will not corrode.

Emerson's integral TXV line includes valves for commercial and refrigeration applications, and heat pump and residential applications. The "Take-Apart Series" TXVs are available for almost any type of application, temperature range, or refrigerant. Emerson also offers a complete line of specialty TXVs.

Factory Superheat Setting

Unless otherwise specified, all Emerson TXVs will be preset at the factory at a bath temperature which is pre- determined by the charge symbol or the MOP rating. The bath temperature at which the TXV superheat is set is coded alphabetically in the superheat block on the TXV nameplate, as shown in Fig. 15.

TXV SUPERHEAT ADJUSTMENT

Valve Family	"Total Turns"	Degrees of SH Per Turn					
		R-22		R-134a	R-404A/507		R-410A
		+20°F	-20°F	+20°F	+20°F	-20°F	+40°F
A	8	3.0	5.0	4.5	2.0	4.0	2.0
C	12	–	–	–	–	–	4.0
HF	10	2.2	4.2	3.8	1.8	3.2	N/A
TF	10	3.0	5.0	4.5	2.0	4.0	2.0
TRAE	10	2.2	4.2	3.8	1.8	3.2	N/A
TCLE	32	0.8	1.5	1.0	0.5	1.0	N/A

Turn adjustment clockwise to increase superheat, counterclockwise to decrease superheat. To return to approximate original factory setting, turn adjustment stem counterclockwise until the spring is completely unloaded (reaches stop or starts to "ratchet"). Then, turn it back in one half of the "Total Turns" shown on the chart.

Fig. 15

For example, a TXV with "10A" stamped in the nameplate superheat block is set for 10°F static superheat with a 32°F bath. A TXV stamped "10C" is set for 10° of static superheat with a 0°F bath.

When ordering a TXV for an exact replacement, specify the code letter and the superheat setting desired. When ordering for general stock, it is not necessary to specify either the superheat or the code letter, since the standard setting will cover most applications and minor superheat adjustments may be made in the field.

Emerson "T" Series TXVs [except "W"-(MOP), G-(MOP) or GS-(MOP) gas charged types] may be installed in any location in the system. The gas charged type must always be installed so that the power assembly will be warmer than the remote bulb. The remote bulb tubing must not be allowed to touch a surface colder than the remote bulb location. If the power assembly or remote bulb tubing becomes colder than remote bulb, the vapor charge will condense at the coldest point and remote bulb will lose control.

For exact TXV selection (i.e., refrigerant tonnage, connections, equalizer style, cap tube length, adjustment and proper application, air conditioning, commercial, low temperature) refer to Emerson catalog.

Emerson MOP

The Emerson "W" charge can be supplied with the MOP feature if needed for system protection. This need rarely occurs in modern day refrigeration except such conditions as immediately after defrost or on gasoline driven compressors such as truck refrigeration.

For special applications, other charges may be used from time to time. For help in selecting a charge with Motor Overload Protection (if required by compressor manufacturer) see the table below and the TXV Charge Selector on page 13.

APPLICATION	R134a	R22	R404A/R507A
COMMERCIAL	MW35	HW65	*W65
LOW TEMP.	MW15	HW35	*W45

* Add refrigerant code as follows: S = R404A, P = R507A

NOTE: MOP **not** available with Rapid Response Bulb.

Superheat adjustment of "W–MOP" charged TXVs will change the MOP point. An increase in superheat setting will lower the MOP point and a decrease in superheat setting will raise the MOP.

TABLE 1 – Maximum Dehydration Temperature (in °F)

	THERMOSTATIC CHARGE					
REFRIGERANT	**L**	**C**	**Z**	**G**	**WMOP/CA**	**X**
R134a	**195**	**190**	**250**	**250**	**250**	**N/A**
R22	**160**	**160**	**185**	**250**	**250**	**N/A**
R404A/R507A	**150**	**150**	**170**	**250**	**250**	**N/A**
R717	**N/A**	**N/A**	**150**	**N/A**	**N/A**	**200**

The table above refers to the maximum dehydration temperatures when the bulb and TXV body are subjected to the same temperature. On **A, L, C, Z,** and **X** charges, 250°F maximum TXV body temperature is permissible **(if the bulb temperature)** does not exceed those shown in the table.

NOTE: Emerson charges "A", "C" and "Z" are liquid cross-charges.

To help you match the correct charge to your specific application, see the TXV Charge Code Selector on the next page. Also provided here are some typical examples of applications by refrigerant charge.

Liquid Charge – L
Ice makers, pilots, liquid injection valves

Liquid Cross-Charges – C, Z
Commercial refrigeration (low & medium temp.), ice makers, transport refrigeration and air conditioning

Gas Charge – G
Air conditioning (including mobile), water chillers

Gas Cross-Charge – CA, AA
Heat pumps and air conditioning

Gas Cross-Charge – HAA
Heat pumps and air conditioning

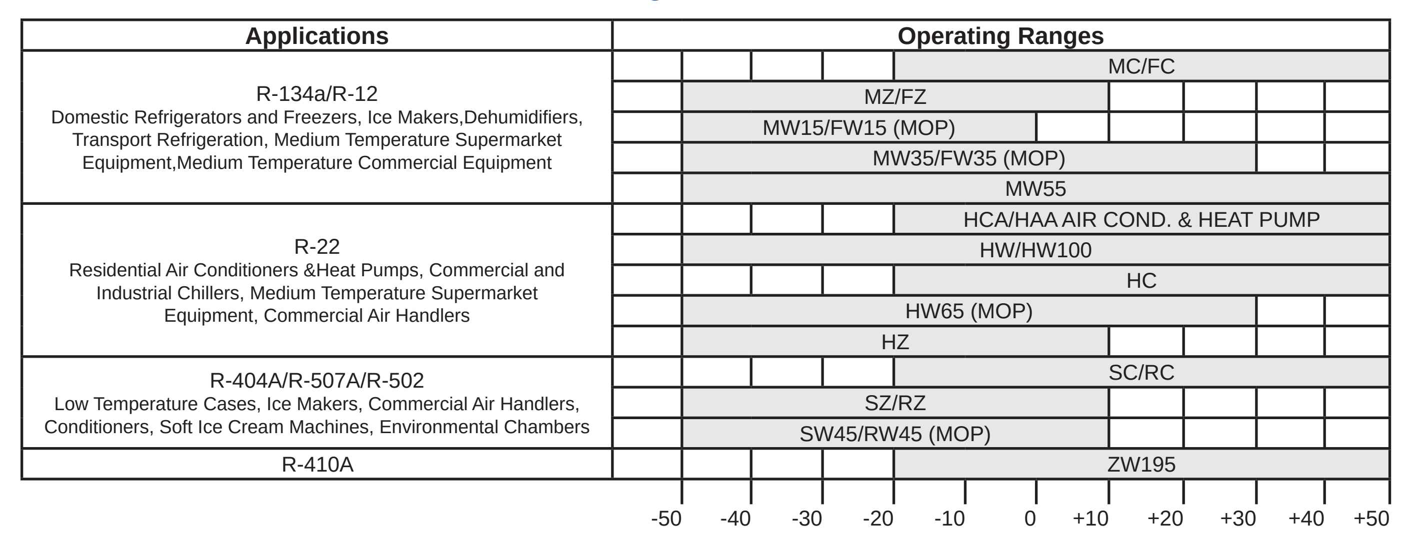
W(MOP)
Maximum Operating Pressure

Refrigerant Code Names

ARI Standard 750-2007 recommends the following color coding of thermostatic expansion valves: R-12 White; R-22 Green; R-502 Orchid; R-40 Red; R-500 Orange. Uncommon refrigerants with no designated color should use Blue.

ASHRAE REF. NO.	TRADE OR CHEMICAL NAME	EMERSON CODE COLOR	EMERSON CODE LETTER
R-12	Dichlorodifluoromethane	WHITE	F
R-22	Chlorodifluoromethane	GREEN	H
R-502	22/115	PURPLE	R
R-134a	Tetrafluoroethane	LIGHT BLUE	M
R-404A	125/134a/143A	ORANGE	S
R-401A	22/152A/124	CORAL	X
R-507A	125/143A	TEAL	P
R-410A	32/125	ROSE	Z

TXV Charge Code Selector



TXV Replacement Charge Symbols Cross Reference

Old Bulb Charges vs. New Replacement Bulb Charge

AIR CONDITIONING		COMMERCIAL REFRIGERATION		LOW TEMPERATURE	
OLD CHARGE	REPLACEMENT	OLD CHARGE	REPLACEMENT	OLD CHARGE	REPLACEMENT
REFRIGERANT R12/R134a					
		F OR FL		—	—
		FC	FC	—	FZ
FW		FW		FWZ	
FG55	FC	FG35		—	—
FW55		FW35	FW35	FW15	FW15/MW15
FQ55		FQ35		FW15	
FGA		—	—	—	—
FLA					
FGS	FWS	FGS35	FGS35		
FWS		FWS	FWS	FWS FZ/MZ FX	FWS FZ/MZ FX
REFRIGERANT R22					
	HC	H OR HL		—	—
		HC	HC	—	HZ
HW	HCA	HW		HWZ	
HG100		HG65		—	—
HW100		HW65	HW65	HW35	HW35
HQ100	HC	HQ65		HQ35	
HGA		—	—	—	—
HLA					
HW85	HW85				
HGS		HGS65	HGS65		
HWS	HWS	HWS	HWS	HWS HZ HX	HWS HZ HX
REFRIGERANT R502/R404A/R507A					
		RL	RC/SC/PC	—	—
RW	RC/SC/PC	RW		RWZ	RZ
RW110		RW65	RW65	RW35	RW45/SW45
RWS	RWS	RWS	RWS	RWS RZ	RWS RZ/SZ/PZ

NOTE: ALL OTHER CHARGE SYMBOLS MUST BE REPLACED WITH AN IDENTICAL MODEL OR AT THE OPTION OF THE EMERSON TECHNICAL SERVICE DEPARTMENT WHO MAY MAKE ENGINEERING AUTHORIZED SUBSTITUTION OF EQUIVALENT TYPE TO PROVIDE EQUIVALENT OPERATION AND PERFORMANCE.
NOTE: FOR FIELD REPLACEMENT PURPOSES, HC CAN BE USED TO REPLACE HCA.

Electronic Valves & Controls



Electronic Valves – Introduction

Thermostatic expansion valves and mechanical regulator valves have been used in the refrigeration and air conditioning industry to control superheat and refrigerant mass flow since the very beginning. As today's systems require improved energy efficiency, tighter temperature control, wider range of operating conditions and incorporate new features like remote monitoring and diagnostics, the application of electronically operated valves becomes mandatory. These valves offer the control performance necessary to meet these needs.

As more new refrigerants appear on the market requiring an ever increasing number of different charges and settings for thermostatic expansion valves, electrical control valves can work with all refrigerants.

Electronic Valve Applications

Valves can be used for a variety of applications:

- Expansion valves
- Capacity control valves
  - Hot gas bypass
    - Controlled by temperature or pressure
- Evaporator pressure regulator
  - Controlled by temperature or pressure
- Liquid injection – oil cooling
  - Desuperheating In screw compressors
- Liquid level control
  - Flooded evaporator
- Crankcase pressure regulator
- Head pressure control

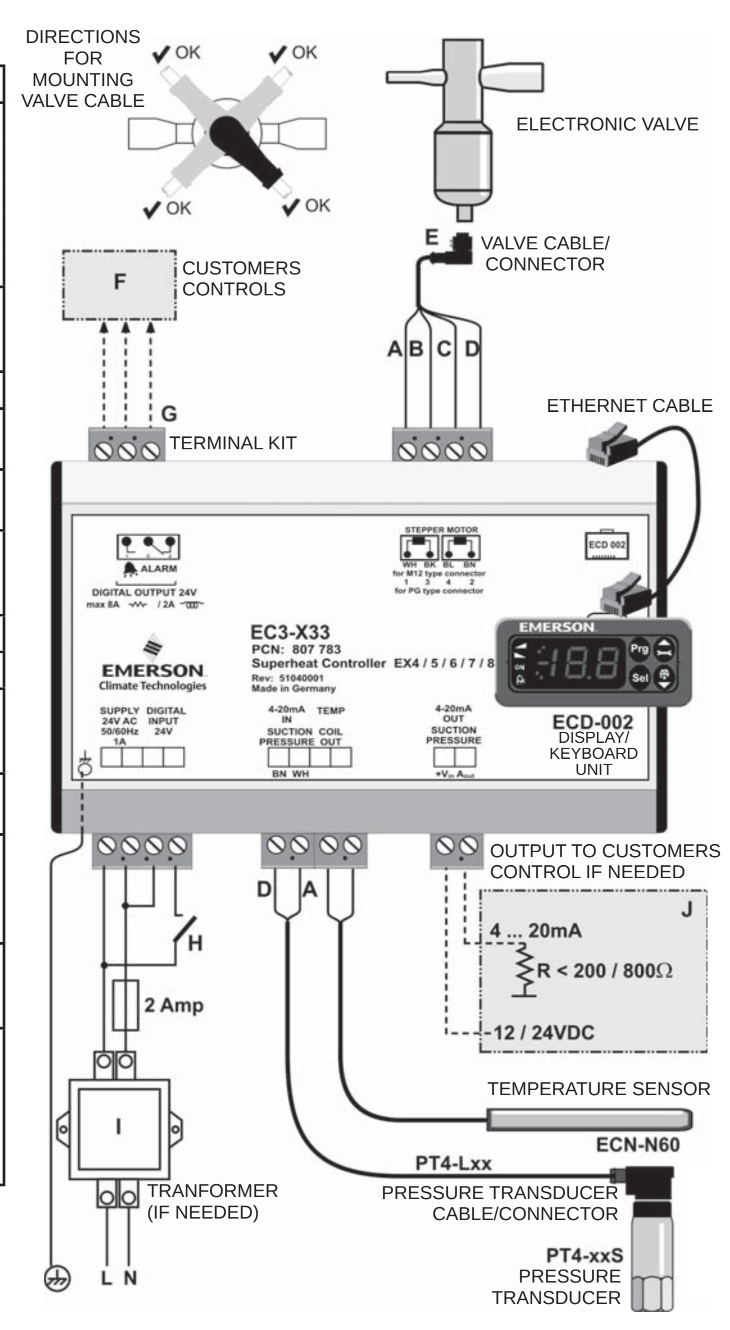
Advantages of Electronic Solution

- Wide operating range
  - Fewer valves to cover the entire capacity and refrigerant range
- Energy savings
  - Allows floating head pressures and provides tighter superheat control
- Suitable for higher pressure refrigerants (R-410A and CO_2)
- Diagnostics and remote monitoring capabilities

Parts Required for Electronic Valves when used as TXV and Driven by Superheat

EC3-32 and EC3-33 Systems

Description	Type	PCN	Notes
Electronic Valves	EX4	097719	Select one valve based on capacity requirements of system
	EX5	097720	
	EX6	097721	
	EX7	097722	
	EX8	097723	
Valve Cable Connector	EX5-N60	097718	Cable used to connect valve to controller EXD-U00
Universal Superheat Controller	EC3-33	097707	Basic SH controller
	EC3-32	097708	Basic with option to connect to PC
Terminal Kit	K03-X32	097711	Needed for EC3 to connect wires
Pressure Transducer	PT4-07M	097715	Use with R22, R134a, R507, R404A, R407C, R124
	PT4-18M	097716	Use with R410A systems
	PT4-30M	097728	Use with R744 systems
Pressure Transducer Cable	PT4-M60	097717	This is required always when transducer ordered
Temperature Sensor	ECN-N60	097714	This is a required item
Display/Keyboard Unit	ECD-002	097712	Must be used with EC3-33 but is an option with EC3-32. Used to set parameters of system
Ethernet Cable	ECC-N30	097713	Used for both ECD-002 and connection to PC thru router
Transformer	T2	097724	Transformer has primary 120/208/240V AC, secondary 24V AC. This is only for customer who cannot obtain 24V AC to run this system.



Temperature Sensor ECN-N60

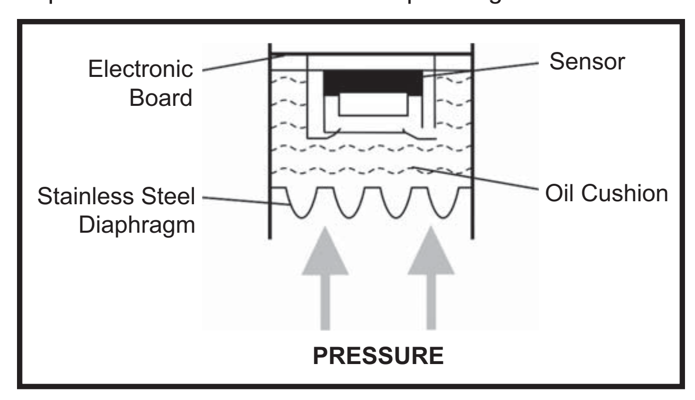
Temperature/Resistance Conversion		
Temperature		Resistance
°C	°F	KΩ
25	77	10,0
10	50	19,9
5	41	25,4
0	32	32,7
-10	14	55,3
-20	-4	97,0
-30	-22	176,7
-40	-40	335,7
-45	-49	470,6

Pressure Transmitter – PT4

The heart of the transmitter is a pressure sensitive piezo resistive cell. This is surrounded by an oil cushion enclosed by a stainless steel diaphragm. The integrated electronic module conditions the output of the pressure cell to produce a temperature compensated signal of 4…20 mA.

The pressure cell consists of a silicon diaphragm with strain gauges diffused into it. A particular advantage of using silicon is its good hysteresis and creeping behavior. The direct integration of the strain gauges means that no additional errors can be introduced between the location where the pressure acts and where it is measured.

Separation of the pressure sensitive element by the oil cushion protects the sensor cell against external mechanical loads such as vibrations, pressure pulsations. This ensures reliable operation and a long life-time expectation even under severe operating conditions.



The protective stainless steel diaphragm ensures compatibility with the media frequently encountered in refrigeration systems. The outside of the PT4 consists of a corrosion resistant stainless steel enclosure. It is sealed at the electrical connector socket and at the pressure connector joint. This way, the PT4 meets the requirements of IP65.

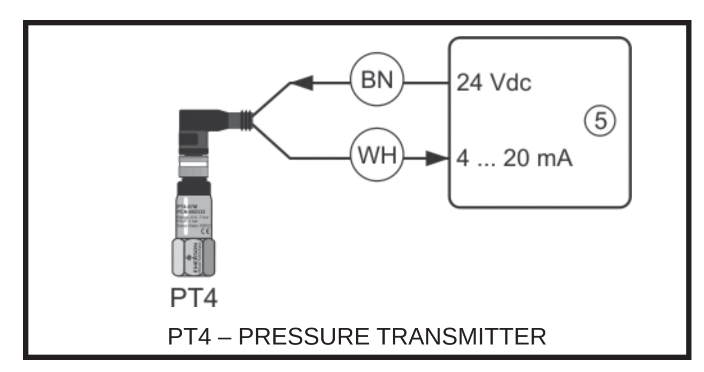
The sensor works internally as an absolute measuring device. However, it is calibrated to produce a relative output signal assuming an ambient pressure of 14.5 psi. When using PT4 in heights significantly above sea level the output signal deviation must be taken into account. i.e. at a height of 1000m the signal reads approximately 1 psi lower than the actual pressure.

Short-term protection against wrong polarity is provided by an internal diode, up to 33 Vdc for the 4...20 mA output version PT4.

PT4 is compliant with the present electromagnetic compatibility legislation and in particular with the EMC directives 89/336/EC complying with EN-61000-6-2, EN-61000-6-3, EN-61000-6-4.

Pressure transmitters PT4 with current output (two wire connection) offer the following advantages:

- More suitable for signal transmission over long distance.
- Higher immunity to electro-magnetic interference.
- Open circuit detection enables fail-safe operation.



PT4 – PRESSURE TRANSMITTER

TXV Controller – EC3-X32

EC3-X32 is a stand-alone universal superheat controller for air conditioning, refrigeration and industrial applications such as chillers, industrial process cooling, rooftops, heat pumps, package unit, close control, cold room, food process and air driers. EC3-X32 offers remote access with built-in TCP/IP Ethernet communications and WebServer functionality. Any standard WebBrowser (e.g. Internet Explorer® 5.0 or higher or Mozilla Firefox) can be used for monitoring or parameter setting.



EC3-X32

The EC3-X32 controls the opening of an electrical control valve according to desired superheat. As Emerson Electrical Control Valves (ECV) are able to provide a positive shut-off function better than conventional solenoid valves, there will be no flow through Emerson ECV as long as the compressor is not running. In the event of cooling request and compressor start-up, EC3-X32 needs to be informed. This can be achieved by a digital input. EC3-X32 will start to control the refrigerant mass flow stand alone by precise positioning of the ECV

under different operating conditions such as compressor start-up, start of further compressor, high head pressure, low head pressure, high load, low load and partial load operation.

EC3-X32 is capable for diagnostics and alarm. The alarm can be received via relay output, via TCP/IP network as well as optical LED/alarm code on ECD-002.

TXV Controller – EC3-X33

EC3-X33 is a stand-alone universal superheat controller for air conditioning, refrigeration and industrial applications such as chillers, industrial process cooling, rooftops, heat pumps, package unit, close control, cold room, food process and air driers. The optional ECD-002 Display/Keypad Unit is necessary for setup but not for operation of the controllers. ECD-002 can be connected or disconnected to EC3-X33 at any time.

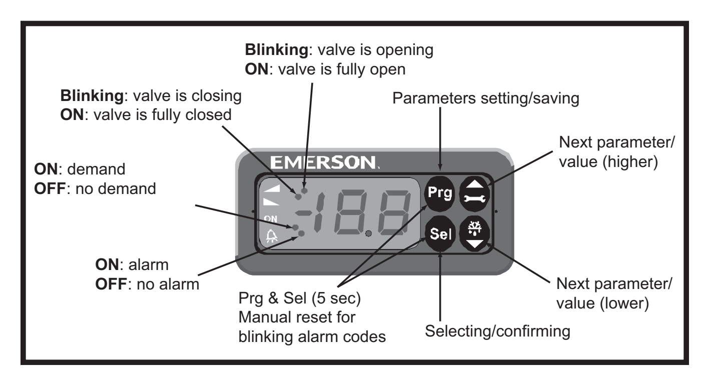


EC3-X33 with ECD-002

Optional ECD-002 Display/Keypad Unit

The ECD-002 is required to set parameters during start-up. After completion of start-up of the EC3-X33, it may be left connected or removed.

The display unit can be switched from K/bar/°C to R/psig/°F. Indicator LEDs show the status of valve opening, valve closing, demand and alarm.

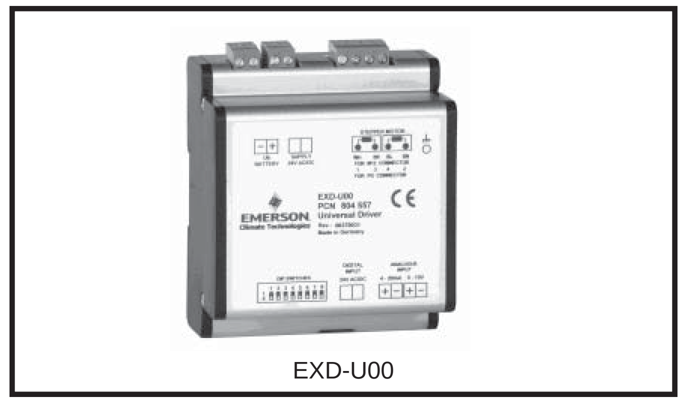


Universal Driver – EXD-U00

EXD-U Universal driver is a stepper motor driver which uses an analogue input signal to define the valve opening. It enables the operation of EX4/EX5/EX6/EX7/EX8 as:

- Electronic expansion valve.
- Capacity control by means of hot gas bypass or evaporating pressure regulator.
- Crankcase pressure regulator.
- Condenser pressure regulator.
- Liquid level actuator.
- Liquid injection valve.

The input signal for the driver module can be 4…20mA or 0…10V. The output pulses provide the proportional opening/closing of EX4/EX5/EX6/EX7/EX8 and consequently the control of liquid or vapor refrigerant mass flow. The universal driver module can be connected to any controller which provides the analogue signal. This gives system manufacturers the extreme flexibility to use any desired controller in conjunction with the universal driver module to achieve different functionality. For further details please refer to EXD-U technical data sheet.



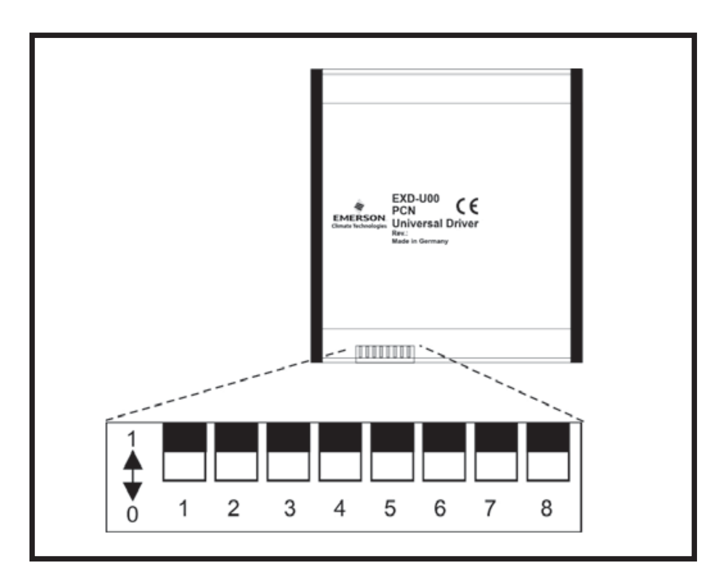
EXD-U00

Third Party Controller

The EXD-U driver simply converts a 4-20ma/0-10 volt signal directly proportional to the valves position of 0-100%, a third party controller is required to supply the input signal to the EXD-U00. The third party controller is typically a programmable, stand alone set point control. It would contain built-in PID control or algorithms capable of being tuned and modified to achieve optimum control of the controlled medium. This signal could also originate from a BAS (building automation system), EMCS (energy management control system) or industrial process controller as long as the signal type is compatible and the proper programming capabilities are available.

Setting

The universal driver needs no setting except configuration with dip-switches for the application of a different valve, different analogue input signal, and type of start mode.



Function	Dip Switch Number							
	1	2	3	4	5	6	7	8
EX4/EX5/EX6 operation	0	1	1	0	1	0	–	–
EX7 operation	1	0	0	1	0	1	–	–
EX8 operation	1	1	0	1	1	1	–	–
4-20 mA analogue input signal	–	–	–	–	–	–	–	0
0-10V analogue input signal	–	–	–	–	–	–	–	1
With start mode	–	–	–	–	–	–	1	–
Without start mode	–	–	–	–	–	–	0	–

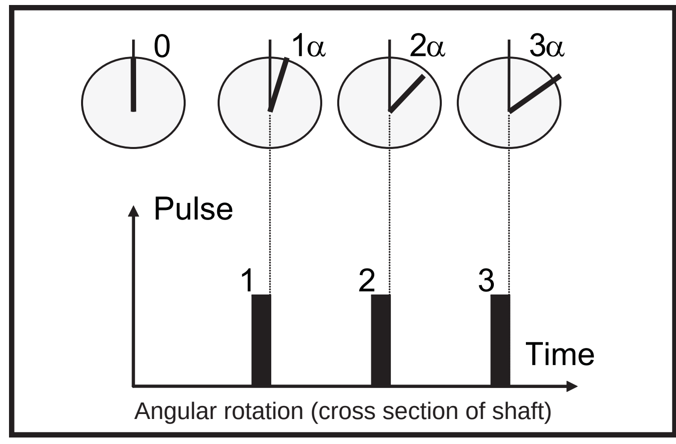
Electrical Control Valve – EX

Function

1) Motor

A 2-phase bipolar stepper motor drives the EX4/5/6/7/8. This motor follows the basic operating characteristics of any stepper motor i.e. the motor will be held in position unless current pulses from a driver board initiate rotation in either direction. The direction of the rotation depends on the phase relationship of the current pulses, the amount of rotation is dependent on the number of pulses. One pulse will drive the motor one step i.e. the rotor will move by α=1.8°. Successive pulses will lead to continuous rotation.

The drive shaft of the rotor is connected to a spindle which transforms the rotation into linear motion of the valve slide.



Angular rotation (cross section of shaft)

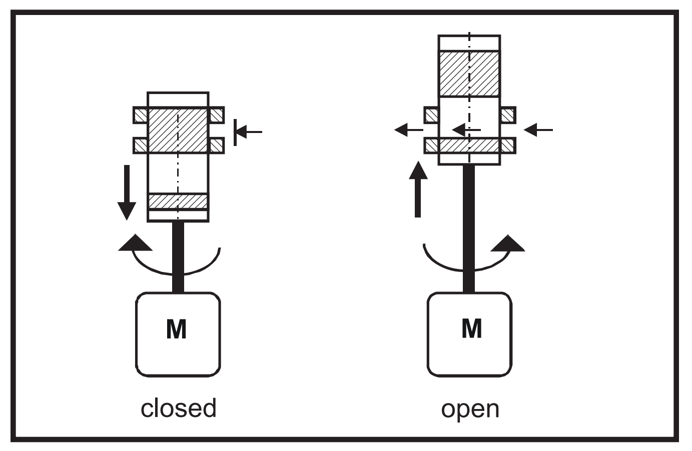
2) Valve

The gate type valve is optimized to provide a wide range of capacity with a linear relation between flow and positioning of the valve (capacity vs. number of steps). Slide and ports are made from ceramic for precise flow characteristics, high resolution and infinite life.

The compliant slide eliminates undesirable horizontal forces caused by differential pressure (across the valve) to the cage assembly and shaft of stepper motor. The internal design of the EX4/5/6/7/8 is patented.

Total valve travel is 750 full steps for EX4/5/6, 1600 steps for EX7 and 2600 steps for EX8.

A mechanical stop in the fully closed position of the valve acts as reference point. The controller is reset by driving the valve towards the fully closed position against the mechanical stop. By overdriving the valve i.e. applying more than the full number of steps, it can be assured that the reference point is correct.

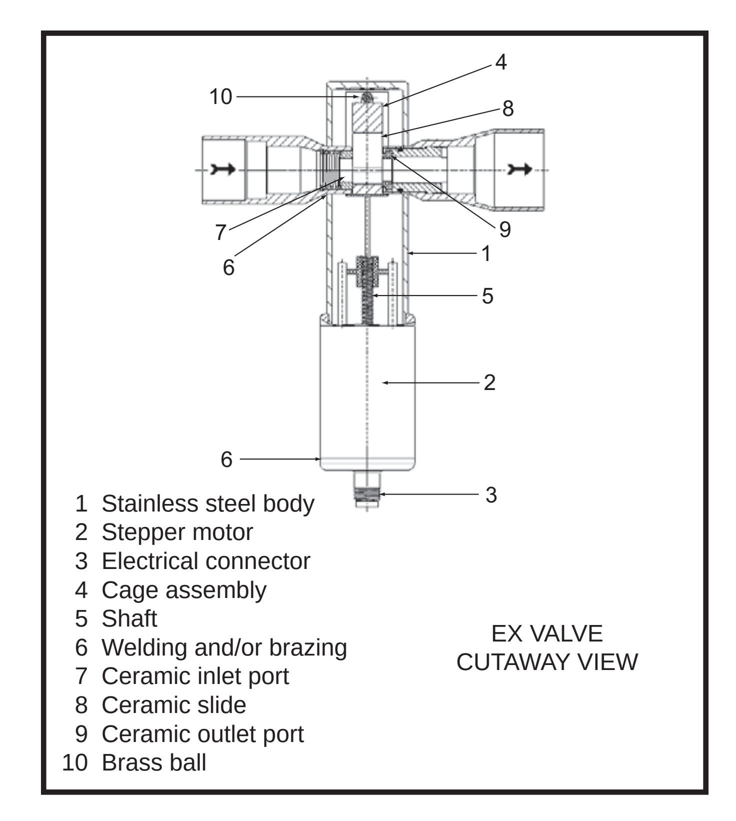


3) Driving of stepper motor

There are many different options to drive stepper motors like the one used in the EX4/5/6/7/8. Emerson stepper motors need a driver board with chopper drive function (constant current), an interface and a controller.

Chopper drive (constant current)

The stepper motor of EX4/5/6/7/8 is a bipolar, 2-phase permanent-magnet motor and operates with constant DC current in each phase.



EX VALVE CUTAWAY VIEW

COMPONENT SELECTION TABLE

COMPONENT	APPLICATION					
	TXV	LIQUID INJECTION	HOT GAS	HEAD PRESSURE	EPR	CPR
KEYPAD (ECD-002)	YES	NO	NO	NO	NO	NO
LAPTOP	*	NO	NO	NO	NO	NO
TEMP SENSOR (ECN-N60)	YES	NO	NO	NO	NO	NO
PRESSURE TRANSDUCER (PT4)	YES	NO	NO	NO	NO	NO
CONTROLLER (EC3-X33)	YES	NO	NO	NO	NO	NO
CONTROLLER (EC3-X32)	*	NO	NO	NO	NO	NO
AUXILLARY CONTROLLER **	NO	YES	YES	YES	YES	YES
DRIVER (EXD-U00)	NO	YES	YES	YES	YES	YES
VALVE (EX)	YES	YES	YES	YES	YES	YES

* Optional
** 3rd party (Emerson does not offer an auxillary controller)

Electronic Valves Programming

Programming Emerson TXV Controller (5):
1) Enter specific data using keypad or laptop computer (i.e. refrigerant, tonnage, superheat, etc.).

Programming a 3rd Party Auxillary Controller (6):
1) Follow manufacturers additional instructions. NOTE: The keypad (1) cannot be used to program these auxillary controllers.

Solenoid Valves



Solenoid Valves

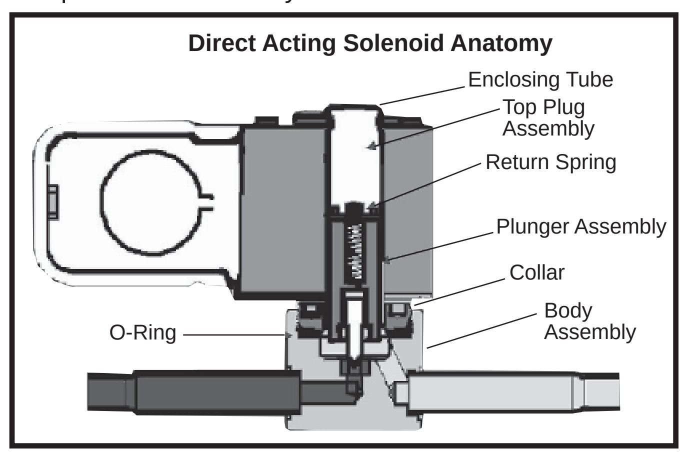
In most refrigeration applications, it is necessary to start or stop the flow in a refrigerant circuit to automatically control the fluids in the system. An electrically operated solenoid valve is usually used for this purpose. Its basic function is the same as a manually operated shut off valve, but by being solenoid actuated, it can be positioned in remote locations and may be conveniently controlled by simple electrical switches.

Solenoid valves can be operated by a thermostatic switch, float switches, low pressure switches, high pressure switches or any other device for making or breaking an electric circuit, with the thermostatic switch being the most common device used in refrigeration systems.

What Are Solenoid Valves?

A solenoid valve consists of two distinct but integral acting parts, a coil and a valve. See drawing below for complete valve anatomy.

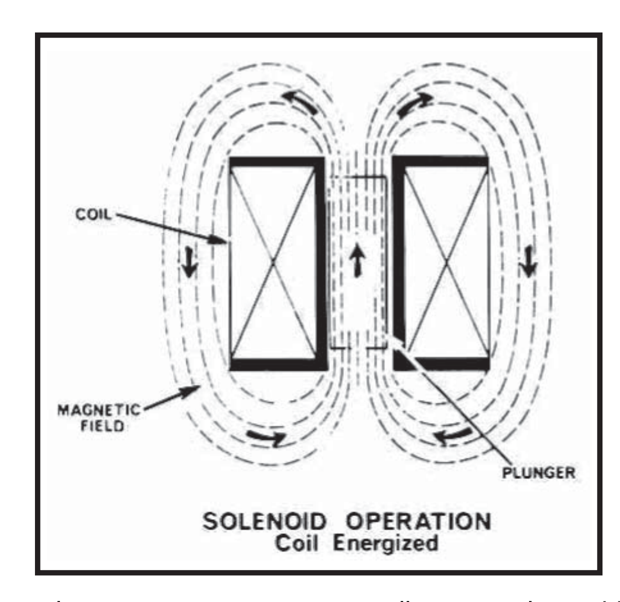
Direct Acting Solenoid Anatomy



The coil is nothing more than electrical wire wound around the surface of a cylindrical form usually of circular cross section. When an electric current is sent thru the windings, they act as an electromagnet. The force field that is created in the center of the solenoid is the driving force for opening the valve. Inside is a moveable magnetic steel plunger that is drawn toward the center of the coil when energized.

The valve contains an orifice through which fluid flows when open. A needle or rod is seated on or in the orifice and is attached directly to the lower part of the plunger.

When the coil is energized, the plunger is forced toward the center of the coil, lifting the needle valve off of the orifice and allowing flow. With a normally-closed valve, when the coil is de-energized, the weight of the plunger and in some designs, a spring, causes it to fall and close off the orifice, thus stopping the flow through the valve. Less common are normally-open valves which are open when the coil is de-energized.



Principles of Solenoid Operation

Solenoids are either direct acting or pilot operated. The application determines the need for either of these types. The direct acting valve is used on valves with low capacities and small port sizes. The pilot operated type is used on the larger valves, eliminating the need for larger coils and plungers.

1. Direct Acting

In the direct acting type valve, as discussed under Solenoid Valve operation, the plunger is mechanically connected to the needle valve. When the coil is energized, the plunger pulling the needle off the orifice is raised into the center of the coil. A direct acting valve will operate from zero pressure differential to its maximum rated pressure differential, regardless of the line pressure.

The direct acting type valve is only used on small capacity circuits because of the increased coil size that would be required to counter the large pressure differential of large capacities. The required coil would be large, uneconomical, and not feasible for large capacity circuits. To overcome this problem on large systems, pilot operated solenoid valves are used.

2. Pilot Operated Valve

The pilot operated solenoid valve uses a combination of the solenoid coil and the line pressure to operate. In this type valve the plunger is attached to a needle valve covering a pilot orifice rather than the main port. The line pressure holds an independent piston or diaphragm closed against the main port. See figures 2a and 2b. When the coil is energized, the plunger is pulled into the center of the coil, opening the pilot orifice. Once the pilot port is opened, the line pressure above the diaphragm is allowed to bleed off to the low side or outlet of the valve, thus relieving the pressure on the top of the diaphragm. The inlet pressure then pushes the diaphragm up and off of the main valve port and holds it there allowing full fluid flow. When the coil is de-energized, the plunger drops and closes the pilot orifice. Pressure starts to build up above the diaphragm by means of a bleed hole in the piston diaphragm until it and the diaphragm's weight and spring cause it to close on the main valve port. A pilot operated solenoid valve requires a minimum pressure difference of several pounds between inlet and outlet to operate.

Types of Solenoids

There are different types of solenoid valves for different applications. The three main types of valves are the 2-way, 3-way, and 4-way valves. The 2-way valve is the most common.

2-Way Valves

The 2-way valve controls fluid flow in one line. It has an inlet and an outlet connection. This valve can be of the direct acting or pilot operated type of valve depending on the need. When the coil is de-energized, the 2-way valve is normally closed. Although normally closed is the most widely used, two-way and three-way valves are manufactured to be normally open when the coil is de-energized. See Figure 3 for an example of a 2-way valve.

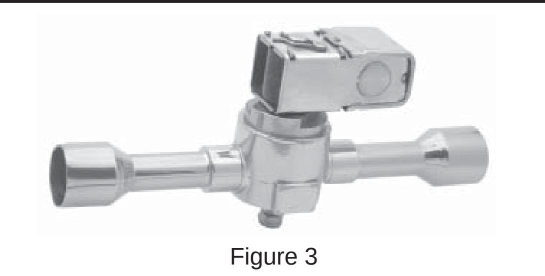


Figure 3

NOTE: 2-way valves are usually designed to have flow in one direction only. Some valves may be modified to have flow in both directions. A “bi-flow” kit must be used.

Figures 1A and 1B show a simple schematic of a Direct Acting Solenoid Valve in operation.

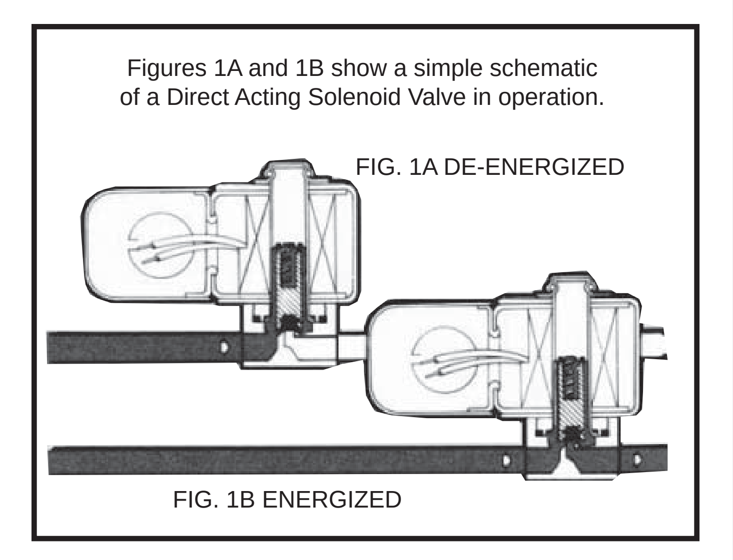


FIG. 1A DE-ENERGIZED

FIG. 1B ENERGIZED

Figures 2A and 2B show a simple schematic of a Pilot Operated Solenoid Valve in operation.

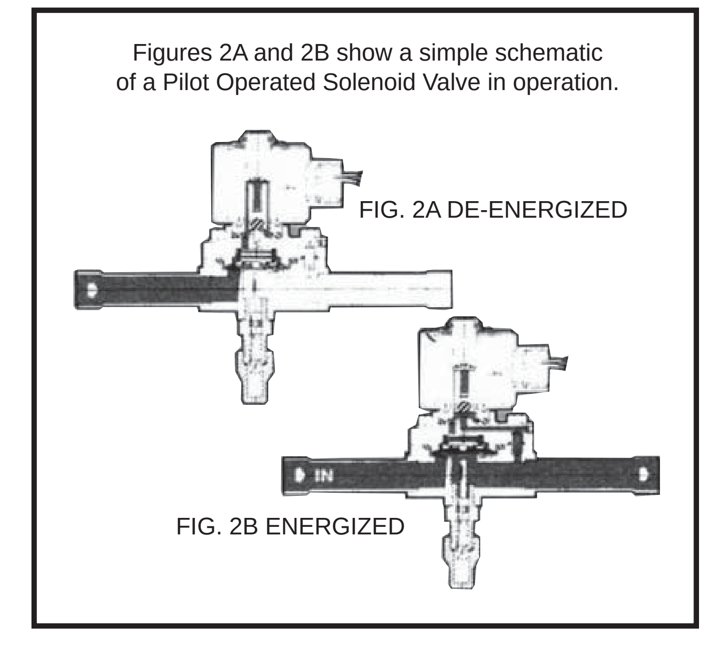


FIG. 2A DE-ENERGIZED

FIG. 2B ENERGIZED

Solenoid Valve Selection

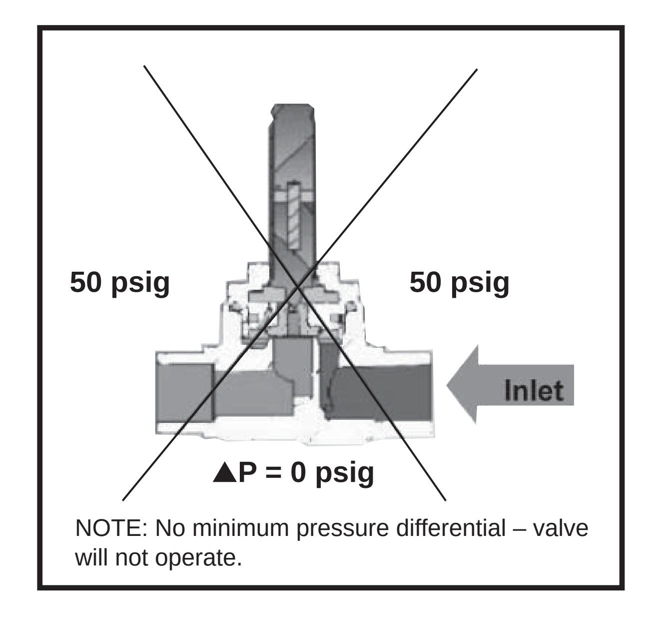
The selection of a Solenoid Valve for a control application requires the following information:
1. Fluid to be controlled
2. Capacity required
3. Maximum operating pressure differential (MOPD)
4. Electrical characteristics
5. Maximum working pressure required (MWP)

The capacities of Solenoid Valves for normal liquid or suction gas refrigerant service are given in tons of refrigeration at some nominal pressure drop and standard conditions. Manufacturers' catalogs provide extended tables to cover nearly all operating conditions for common refrigerants. Follow the manufacturer's sizing recommendations. Do not select a valve based on line size. Pilot operated valves require a pressure drop to operate and selecting an oversize valve will result in the valve failing to open. Undersized valves result in excessive pressure drops.

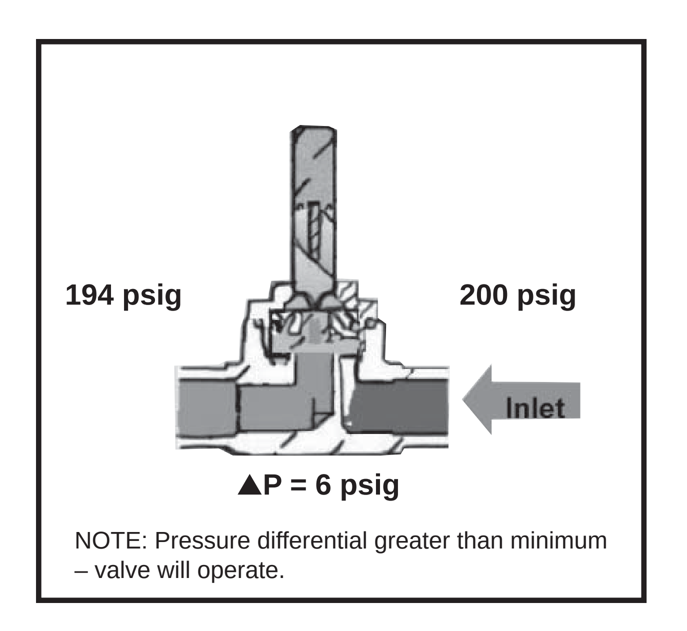
The solenoid valve selected must have a MOPD rating equal to or greater than the maximum possible differential against which the valve must open. The MOPD or Maximum Operating Pressure Differential considers the inlet and outlet valve pressures. If a valve has a 500 psi inlet pressure and a 250 outlet pressure, and a MOPD rating of 300 psi it will operate, since the pressure difference (or 500-250) is less than the 300 MOPD rating. If the pressure difference is larger than the MOPD, the valve will not open.

Minimum Operating Pressure Differential

Consideration of the maximum working pressure required is also important for proper and safe operation. A solenoid valve should not be used for an application when the pressure is higher than the valve maximum working pressure. Solenoid valves are designed for a given type of fluid so that the materials of construction will be compatible with that fluid. Special seat materials and synthetics may be used for high temperature or ultra-low temperature service. Special materials are required for corrosive fluids. Special attention to the electrical characteristics is also important. Required voltage and Hertz must be specified to ensure proper selection. Valves for DC service often have different internal construction than valves for AC applications, so it is important to study the manufacturer's catalog information. Solenoid valves should never be used as a Safety Shut Off unless specifically designed and rated for that service.



NOTE: No minimum pressure differential – valve will not operate.



NOTE: Pressure differential greater than minimum – valve will operate.

Installation

Solenoid Valves having a spring loaded piston or diaphragm may be installed and operated in any position, but installing more than 90° from vertical is not recommended since dirt or debris may collect in the solenoid area and prevent it from operating. An adequate strainer or filter drier should be installed ahead of each solenoid valve to keep scale, pipe dope, solder, and other foreign matter out of the valve.

When installing a solenoid valve, be sure the arrow on the valve body points in the direction of refrigerant flow.

When brazing valves with extended solder type connections do not use too hot a torch and point the flow away from the valve. These valves do not normally need to be disassembled before installation; if the valve does not have extended connections, disassemble the valve before brazing. Wet rags or chill blocks are recommended during brazing. They are needed to keep the valve body cool so that body distortion on close-coupled valves will not occur. Allow the valve body to cool before replacing the valve's operating insides to ensure that the seat material and gaskets are not damaged by the heat. When reassembling, do not over torque.

Emerson Solenoid Valves

Emerson offers a complete line of refrigerant solenoid valves for refrigeration and air-conditioning applications. As part of Emerson's commitment to the industry, each valve undergoes stringent Emerson testing to ensure fail-safe operation. And, with the lowest external leak rates in the industry, Emerson solenoid valves ensure precise refrigerant flow, preventing system failures and aiding in environmental protection.

Application Overview

Application	Product Family
Liquid, Suction Line Service or Hot Gas By-Pass	**240RA/540RA 50RB 100RB 200RB/500RB**
Pressure Differential Valve for Gas Defrost	**710RA 713RA**

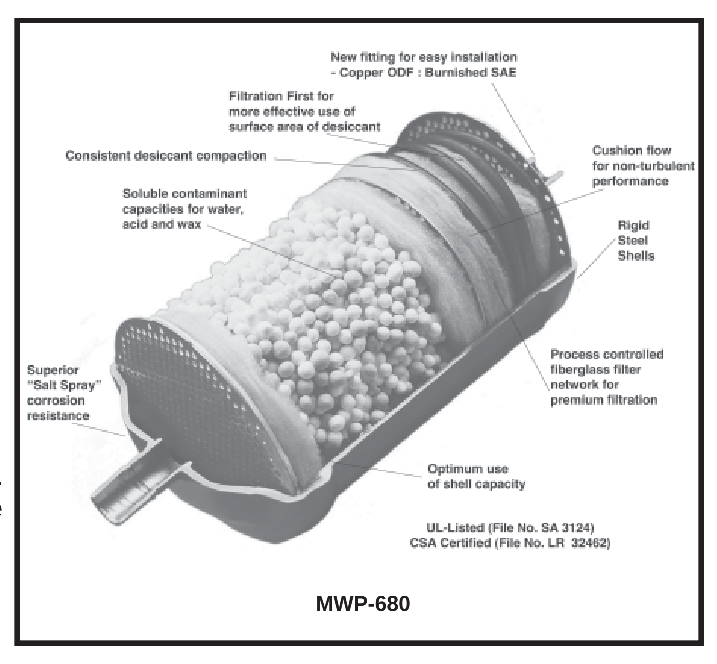
System Protectors



Liquid line and suction line filter driers are often referred to as System Protectors because they remove harmful elements from the circulating refrigerant before serious damage results.

Keeping the system clean and free of foreign contaminants that can restrict the operation of valves, block capillary tubes or damage compressors is the best way to assure trouble-free operation. These contaminants can be solids, such as metal filings, flux, dust and dirt. Other equally menacing contaminants are solubles, such as acid, water, resins and wax.

No matter how many precautions are taken during assembly and installation or servicing of a system, contaminants can find a way into the system. Filter-driers are designed to protect a system during operation. It is the function of this all important unit to remove those residual elements that can attack and eventually destroy the system components.



MWP-680

Filtration Capacity

Solid particles or semi-solids such as sludges circulating in a refrigerant system can destroy valve seats, plug control valves, and score cylinder walls or compressor bearings. These contaminants can be the result of manufacturing, servicing, or can be generated during normal system operation.

It is important to remove these contaminants as quickly as possible and prevent them from returning to the system. Properly specified filter driers are designed to trap and hold large quantities of these contaminants while maintaining low pressure drop during their service life.

Moisture Capability

Moisture in a refrigeration system can cause frozen valves, copper plating, damaged motor insulation, corrosion, and sludges. Filter driers remove and retain moisture through one or more desiccants. The most popular and effective desiccant in use today for the removal of moisture is molecular sieve which can hold three to four times the water of other commercial absorbents.

Moisture capacity of a filter drier is normally given in drops of water per ARI Standard 710. These rated capacities are in addition to any residual moisture that might be absorbed during manufacturing.

Acid Pick-Up Capability

Various organic acids result during the decomposition of the refrigerant and oil in a system. This decomposition can be the result of moisture in the system, excessive temperatures, air, or exposure to foreign substances in the system. It is important that acid in a system is absorbed as soon as it is formed to prevent the acid from causing system damage. Activated alumina is the most popular of the desiccants used to remove acid.

Tests have shown that the amount of acid and resin pick-up of an adsorbing agent is almost proportional to the weight of the desiccant. Size or granulation makes little difference.

There is no industry-approved method for rating acid removal. So weight of the desiccant provides the handiest measure.

Wax Removal

The ability of a filter drier to remove wax and resins is important in low temperature applications that use R-22. Wax when present in a system tends to solidify on valve seats and pins, resulting in system malfunctions.

Flow Rate

Published flow rates for filter driers are established in accord with ARI Standard 710 for liquid line driers, and ARI Standard 730 for suction line driers.

Absorption vs. Adsorption

One factor to consider in selection is ab- vs. adsorption. Absorption means a material's ability to take another substance into its inner molecular structure.

An adsorbed substance doesn't penetrate the molecular structure. It simply starts building up on the surface of the adsorbent. Walls, cracks, crevices are part of the surface area and are able to hold other substances, greatly increasing capacity.

Modern desiccants are extremely porous and have a large surface area and internal pore volume of a size and shape to adsorb and retain water molecules.

Types of Filter driers

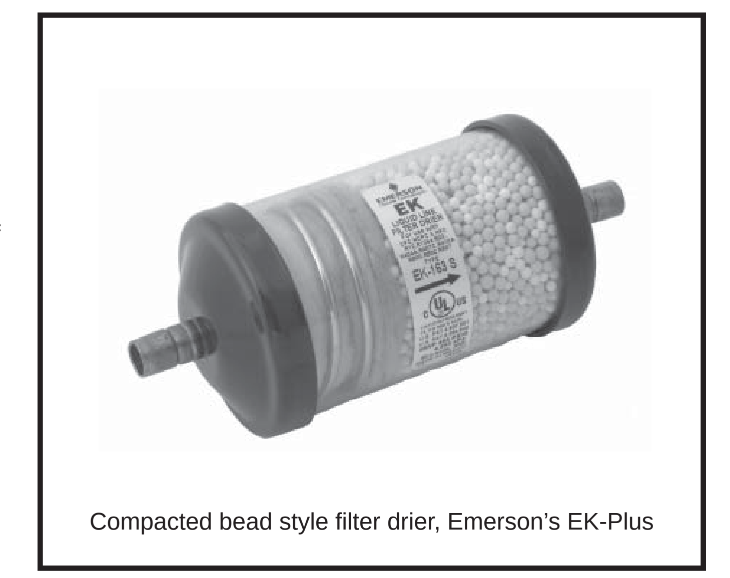
All the liquid line filter driers on the market today are a variation of one of two types: the molded core type or the bead type.

Molded core type filter driers are manufactured by mixing desiccants (which remove the soluble contaminants) with a bonding agent, then baking them to give them permanent shape and to activate the drying ingredients. The result is a porous core which acts as filter and drying agent.

Compacted bead style filter driers are manufactured with the active desiccant in bead or pellet form; no bonding material is used. Rather, compacting comes from mechanical pressure exerted by a spring. Compacted bead-style filter driers usually include an additional filter network to trap solid contaminants from the refrigerant, unlike most core styles.

The separate and distinctive filter media can take various forms that permit depth filtration with greater solid contaminant capacity and contaminant retention during start-up and shut- down when turbulent conditions exist.

Compacted bead filter driers offer the maximum volume of desiccant because filtering and drying is done in one mass. But, because a molded core is porous, it does not hold all solid contaminants; often particles are washed through channels within in the core when pressures surge. Better holding power is possible with a more compacted core. But pressure drops increase inversely.



Compacted bead style filter drier, Emerson's EK-Plus

Dirt, Waxes, Acid

Every system has contaminants in it as soon as it is opened. These contaminants may be insoluble, such as metal filings not removed in manufacturing, or airborne dirt that entered when the system was opened. Or they may be soluble, such as waxes, acids, water and resins that develop through reactions between air, the refrigerant, or lubricant.

Any of these can cause system failure. Installing an all-purpose filter drier can lessen chances for trouble.

There are basic differences to consider: type of filter, how it filters, and its true capacity.

Most manufacturers rate their filters to ARI Standard 710. But even though two clean filter driers may be rated the same, there can be a vast difference in flow as the quantity of solids picked up increases.

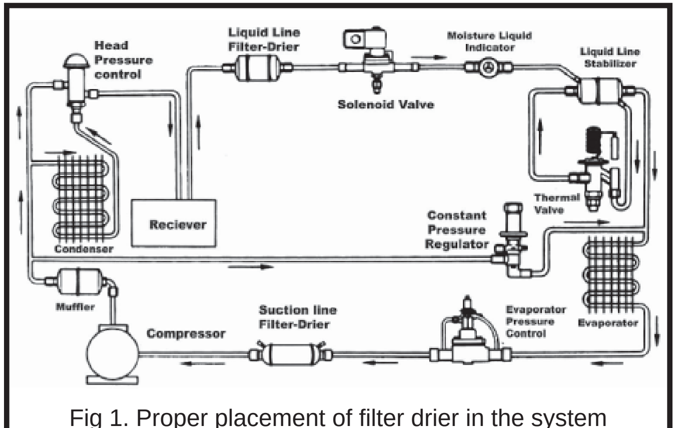
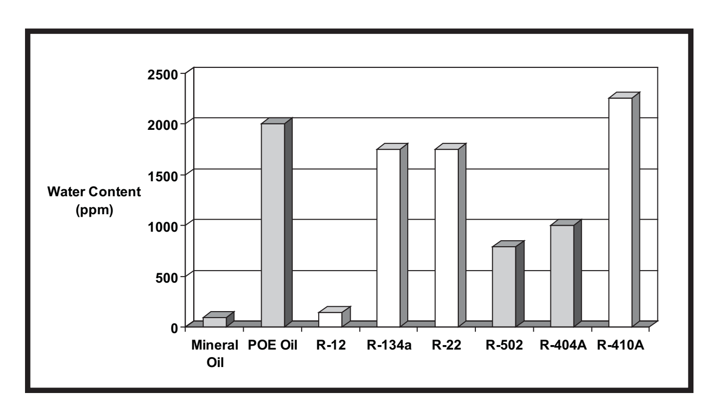


Fig 1. Proper placement of filter drier in the system

HFC Refrigerants and POE Lubricants

The use of HFC refrigerants and Polyolester (POE) lubricants for air-conditioning and refrigeration has generated new system chemistry related problems. New and redesigned system protectors have been developed to counter these problems and provide a long, reliable life for the operating refrigeration system.

Moisture is the major problem causing contaminate for HFC/POE oil systems just as it was for CFC and HCFC systems using Mineral oil. Many HFCs can hold much more water than their CFC counterparts but the oil differences are much worse than those of the refrigerant. POE oil can hold as much as 10 times more water than Mineral oils. Evacuation alone has proved ineffective at removing this moisture so a filter drier is required to perform this function.



Water poses a new problem for POE oils above and beyond those experienced with Mineral oil. POE oil will react with water to form organic acids at normal operating conditions in refrigerating and air-conditioning systems. This reaction starts at water levels as low as 75 ppm. These acids attack system components including motor insulation and metallic parts, reducing system life.

To combat the detrimental effects of water in HFC and POE oil systems it is imperative to hold moisture levels as low as possible. Water level must be maintained less than 50 ppm in the refrigerant and the same for the oil.

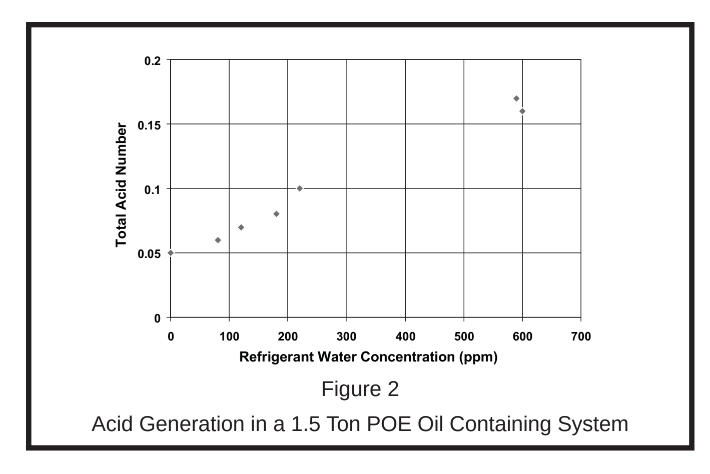


Figure 2

Acid Generation in a 1.5 Ton POE Oil Containing System

Another aspect of POE oil is the ability to keep more solid particles in suspension than Mineral oil. This is important in retrofitted systems where pockets of solid contamination are now flushed from low flow areas and need to be removed before moving parts in the system are damaged. The filter drier for POE oils needs to have higher solid particle holding capacity with little impact to refrigerant flow capacity or pressure drop.

The filter drier should also have improved contaminate removal efficiency as well to ensure that all particles are captured the first time they enter the filter drier. The ability to remove smaller particles is also advantageous. The Emerson EK series filter driers provide a unique combination of these characteristics to provide outstanding filtration as shown in Figure 4.

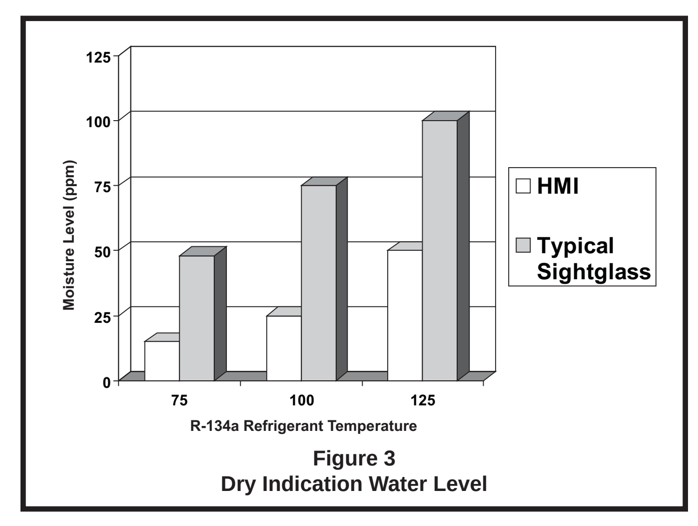


Figure 3
Dry Indication Water Level

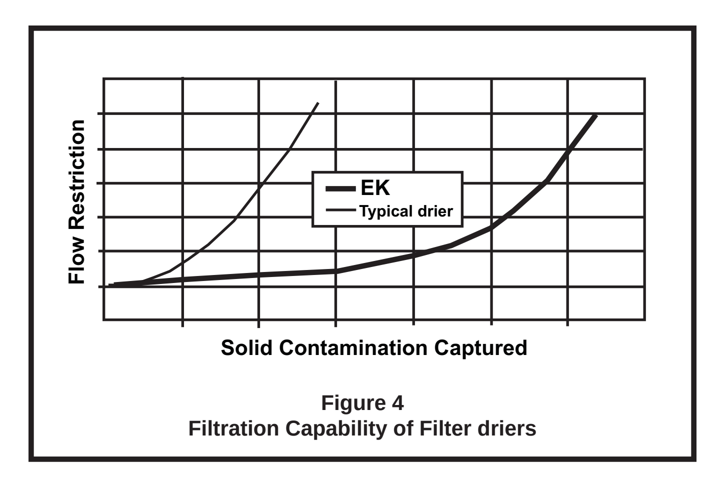


Figure 4
Filtration Capability of Filter driers

The filter driers for use in HFC and POE oil systems must keep the system dry and free of any acids generated. However, since water capacity is of primary importance the filter drier should contain a higher percentage of molecular sieve than was required for CFC and HCFC systems. But molecular sieve alone is not enough since it has almost no organic acid capacity. An organic acid removal desiccant must be used such as activated alumina to ensure low acid levels are maintained. The filter drier should also have higher filtration capacity and efficiency. The EK series of filter driers provides the best combination of these properties to ensure the long, trouble-free life of any air-conditioning or refrigeration system.

The moisture indicating sightglass must also indicate moisture levels less than 50 ppm moisture. Also, it must be able to perform this function at the temperature of the liquid line on which it is placed. Many sightglasses cannot perform this function at all liquid line temperatures. This low level indication ability is needed to ensure that the system moisture never exceeds the level at which organic acid formation starts. The Emerson HMI moisture indicating sightglass provides this low level detection ability.

Suction Filter Driers

The function of filter driers in refrigeration and air conditioning systems is to trap moisture and harmful contaminants. But their use in the **liquid** line still tends to be thought of as the “standard” application; including them also in the **suction** line hasn’t yet become standard practice to the same degree.

A filter drier in the liquid line essentially protects the system controls – solenoid valves, expansion valves, and pressure regulators. The function of the filter or filter drier in the suction line is specifically to protect the compressor against contaminants.

Such protection is encouraged by compressor manufacturers in any case, but there are two circumstances that make suction line filters or filter driers advisable.



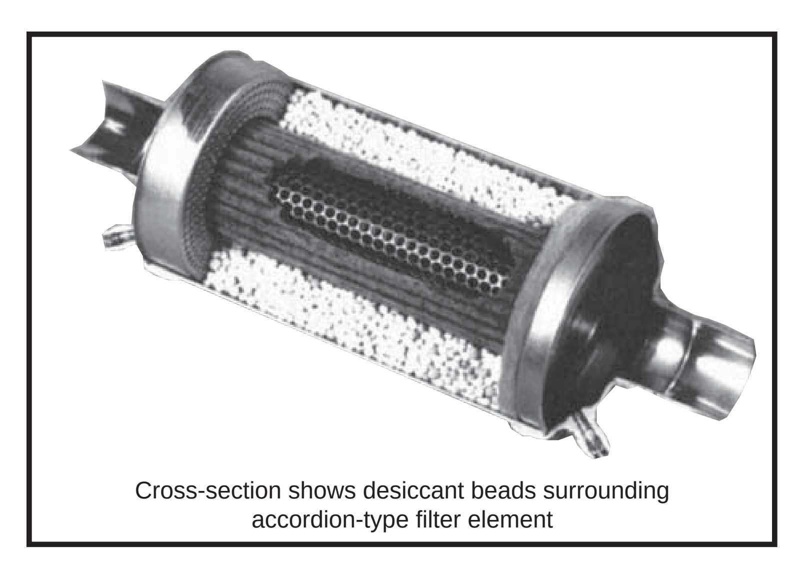
Emerson ASD suction line filter drier

Field Built-up Systems

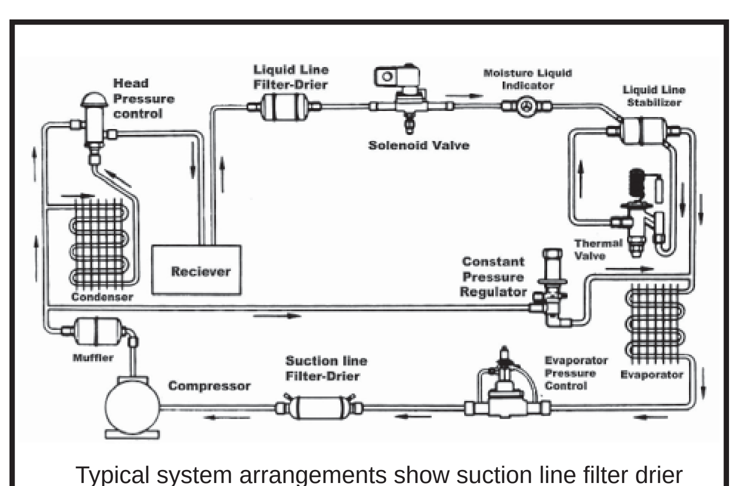
It is practically impossible to avoid contamination when assembling a refrigeration system in the field. Dirt, moisture, metal particles, and copper oxide from brazing all can be present in the system despite the greatest care, and all can damage are reduce the service life of the compressor.

In large and complex systems, such as a single system serving several food cases throughout a supermarket, it is a generally accepted practice to install a cartridge-type filter in the suction line. Then, because of the virtual certainty of contamination during assembly of the system, the initial cartridge is removed and replaced after the first few days of system operation.

When considering the price of a compressor, the cost of protecting it with a suction line filter is insignificant.



Cross-section shows desiccant beads surrounding accordion-type filter element



Typical system arrangements show suction line filter drier installed ahead of the compressor.

Internal Design

Internally, suction line filter driers employ the same types of elements as liquid line units. One is the core type, in which the filter drier consists of a rigid, cylindrical, porous core that may perform both the filter and drier functions, or be used in combination with a separate accordion-type filter element.

The core type filter drier is available either in a hermetically sealed configuration or in take-apart designs with a replaceable element.

The latest advancement is the bead-type unit, in which the desiccant is compacted into the shell. This design offers several advantages over older types, including lower pressure drop, more desiccant surface area, and greater capacity.

Application Tips

Using a liquid line filter drier as a suction line filter drier is not recommended. A suction line filter drier should provide for greater capacity than a liquid line unit, for better compressor protection and for less pressure drop. Two access valves are required to measure pressure drop across the suction line filter drier.

Compressor Burnout

A compressor burnout can be expected to release a variety of pollutants into the system, including acids. The clean-up procedure below describes the use of system protectors in cleaning up a system.

Clean-Up Procedure for Compressor Motor Burnout

1. Determine the extent of the burnout. For mild burnouts where contamination has not spread thru the system it may be economical to save the refrigerant charge, if the system has service valves on the compressor. A severe burnout exists if the oil is discolored, an acid odor is present, and contamination products are found on the high and low side. In this condition, caution should be exercised to avoid breathing the acid vapors. Also, avoid skin contact with the contaminated liquid.

2. Thoroughly clean and replace all system controls such as TXVs, solenoids, check valves, and reversing valves. Remove all strainers and filter driers.

3. Install replacement compressor and make a complete electrical check.

4. Make sure that the suction line near the compressor is clean. Install an over-sized liquid line filter drier and a suction line filter drier.

5. Pressure and leak-test the system according to unit manufacturer's recommendations.

6. Triple evacuate to at least 200 microns. Break the vacuum with clean, dry refrigerant at 0 psig.

7. Charge the system through an Emerson EK filter drier to equipment manufacturer's recommendations.

8. Start the compressor and put the system in operation. Record the pressure drop across the suction line filter drier on the enclosed label and apply label to the side of the shell.

9. Replace the suction line filter drier if the pressure drop becomes excessive.

10. Observe the system during the first 4 hours. Repeat step 9 as often as required, until no further change in pressure drop is observed.

11. After the system has been in operation for 48 hours, check the condition of the oil with an acid test kit. If the oil test indicates an acid condition, replace the liquid and suction line filter driers.

12. Check the system again after 2 weeks of operation. If the oil is still discolored, replace the liquid and suction line filter drier.

13. Clean-up is finished when the oil is clean and odor-free, and is determined to be acceptable with the acid test kit.

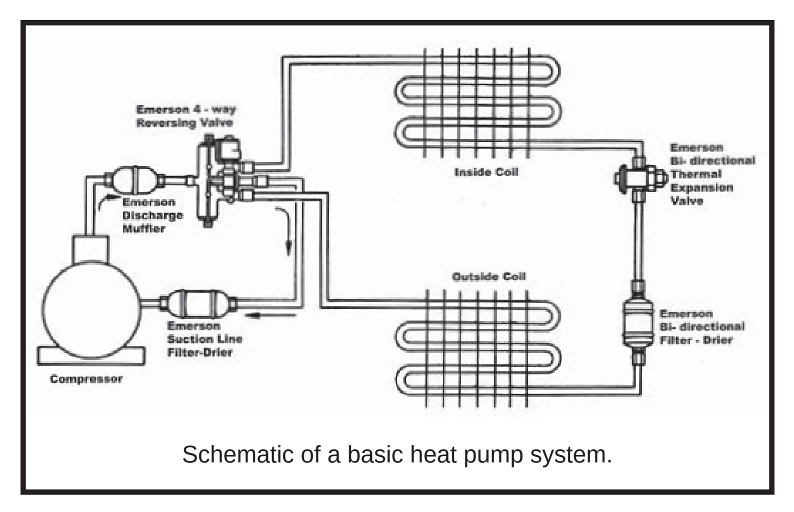
For detailed burnout clean-up procedure and recommendations, consult the RSES Service Manual, Section 91.

Filter Driers for Heat Pumps

A heat pump is essentially a refrigeration system that can flow in either direction. The key to its operation is a four-way reversing valve that routes the discharge gas from the compressor.

Depending on whether the system is cooling or heating, the indoor and outdoor coils swap roles, taking turns serving as the condenser and evaporator.

Since conventional refrigerant control components are designed for unidirectional operation, their use in heat pumps requires installation in pairs, one for each direction, with check valves routing the flow through or around them. Today, because of the growing use of heat pumps, components such as thermostatic expansion valves are available in bi-directional versions, as are filter driers.



Schematic of a basic heat pump system.



Emerson BKF bi-directional pump filter drier

Removing Contaminants

Just like any other refrigeration system, heat pump system components need filter drier protection to remove solid and soluble contaminants. This may be handled several ways.

First, in systems with one-way expansion valves and check valves, a one-way filter drier might be installed in series with a check valve. This would be a “part-time” arrangement, in that filtration would be provided in only one direction.

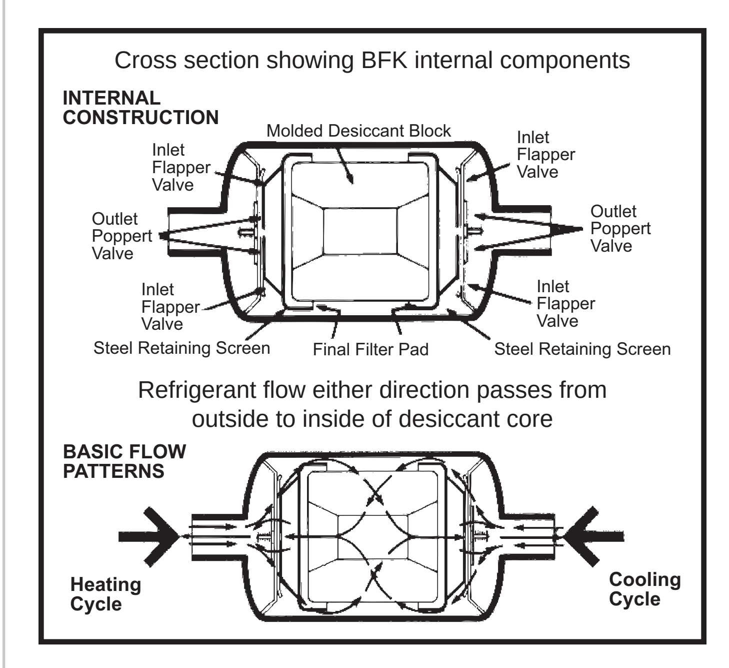
Second, a one-way filter drier might be installed with each of the check valves, so that one provides filtration in each direction.

Third, the simplest arrangement is to install a bi-directional filter drier in the common liquid line. Used in combination with a bi-directional thermostatic expansion valve such as Emerson’s HF series, the complexity of multiple expansion valves, check valves, and filter driers can be completely eliminated.

One-Way Flow, Both Ways

Inside a bi-directional filter drier the refrigerant always flows the same direction regardless of which way the refrigerant is flowing through the system. The internal flow in this case is controlled by an inlet flapper valve and an outlet poppet valve on each side of the desiccant core. As the liquid enters the filter drier from either direction, the inlet flapper valve routes it to the outside of the desiccant core. After it flows through to the inside of the desiccant core, it exits through the opposite poppet valve.

The purpose of the arrangement shown below is to prevent contaminants collected in one direction from being flushed back out when the flow reverses.

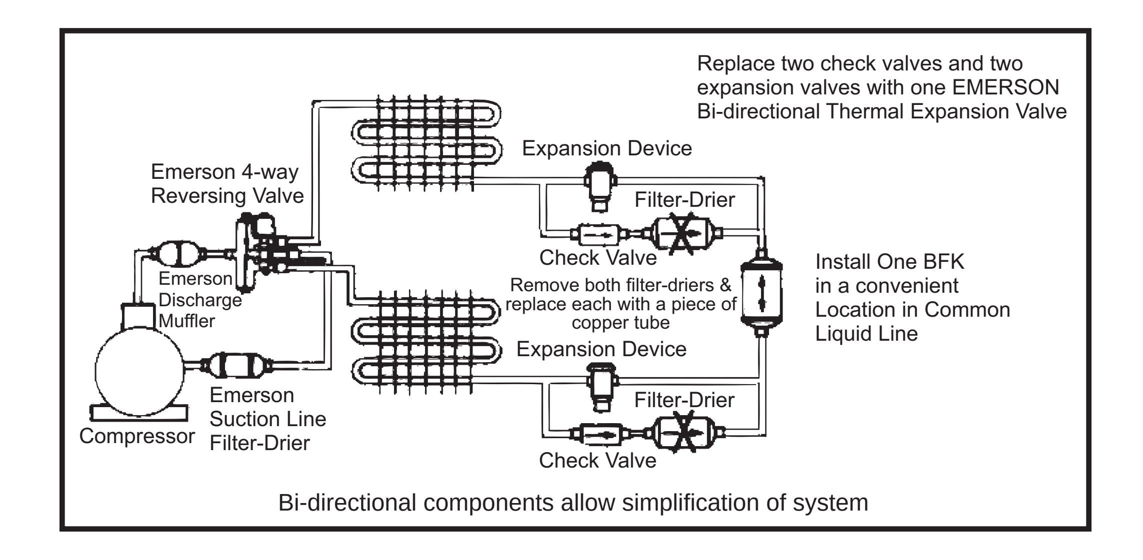


Simplifying While Servicing

When servicing or repairing heat pump systems, especially older units, it's a good idea to simplify them by replacing unidirectional driers and check valves with bi-directional driers. When a bi-directional filter drier is installed, check valves, and filter driers can all be replaced at once with copper tubing.

Emerson System Protectors

Emerson filter driers were redesigned for increased water removal capacity to reach these low moisture levels. However, since no system is entirely without water on startup some organic acids will be generated and must be removed. The desiccant formulation for the Emerson EK series of filter driers was designed to provide the best mix of water capacity and acid capacity to ensure that harmful contaminates are removed. This desiccant mixture contains molecular sieve and activated alumina. The molecular sieve is specifically designed to provide maximum drying in today's systems. The activated alumina is ideal for capturing the large organic acids that the molecular sieve cannot.



Bi-directional components allow simplification of system

Regulators



Types of Regulators: Suction Line Regulators

Suction line regulators provide a wide variety of refrigerant control functions, but are mainly used for regulating suction gas pressures. These regulators provide a method of balancing the output of the refrigeration system with the load requirements. Two basic types are covered here:

1) Upstream pressure regulators, which control from an inlet pressure signal.
2) Downstream pressure regulators, which control from an outlet pressure signal.

Application of Evaporator Pressure Regulators

Evaporator Pressure Regulators are normally used on multiple-compressor refrigeration systems fed by TXVs, low side floats or solenoid liquid valve and float switch combination. They are used whenever a minimum evaporator pressure or temperature is desired. Controlling from an inlet side pressure signal, they prevent upstream pressure from going below a pre-set point.

EPR valves are used on brine or water chillers to prevent freeze-up during low load periods, by keeping the refrigerant saturation pressure above the fluid freezing temperature. Similarly, they may be used to prevent frost formation on fan coil evaporators. They may also be used to provide a given evaporator saturation pressure to produce the required evaporation/room temperature difference, (especially useful where humidity control is required). On multiple evaporator systems where different evaporator temperatures are required, EPR valves will hold the saturation pressure at the required set point above the common system suction pressure. Here, the EPRs prevent lowering of the desired temperature in the warmer evaporators, while the compressor continues operating to satisfy the coldest evaporators. See figure 1.

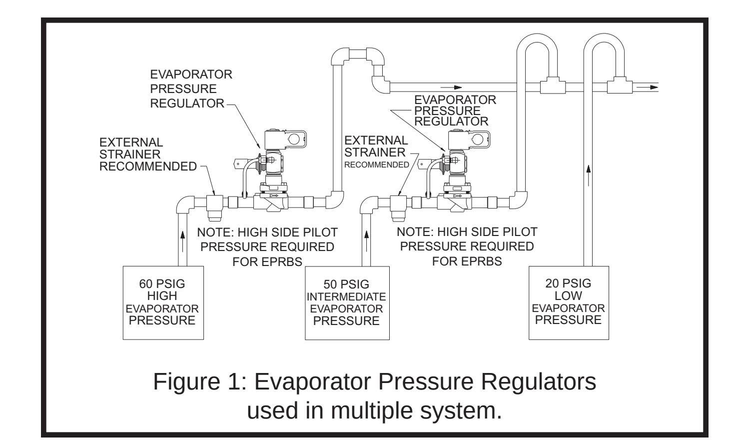


Figure 1: Evaporator Pressure Regulators used in multiple system.

EPR Installation

EPRs may be installed at the compressor rack or close to the evaporator.

Suction line regulators can be direct acting or internally piloted such as an Emerson IPR regulator. These are hermetically sealed, non-repairable valves for use on low capacity systems.

For higher sensitivity and accurate control, an externally piloted EPRB regulator will provide control of larger units. These are repairable in the line. The EPRB valve is a lightweight, brass body valve which eliminates the need for normal system pressure drop needed to make the valve move through the full stroke. This is accomplished by using compressor discharge gas to pilot the regulator.

Combining an EPRB with a suction stop or shut off is done with the EPRBS models. When the pilot solenoid is de-energized, the valve closes. This eliminates the cost of a separate suction solenoid and offers a tight shut off.

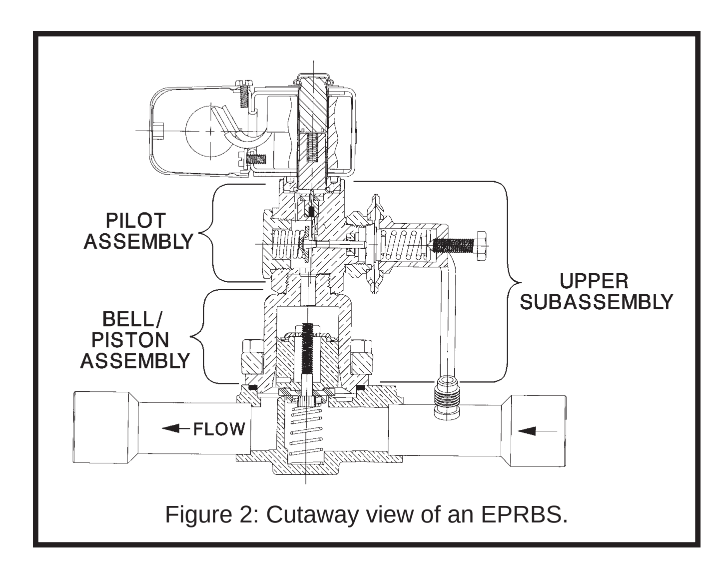


Figure 2: Cutaway view of an EPRBS.

Upstream Regulators

The sole function of the Evaporator Pressure Regulator is to prevent the evaporator pressure from falling below a predetermined pressure setting. This enables the system to meet certain load requirements over a wide range of conditions and offers improvement over the simple “on-off” compressor control usually provided by thermostats or pressure switches.

Downstream Pressure Regulators

Suction pressure regulators are used to prevent compressor motor overload. By throttling the suction gas flow during high load conditions, the compressor motor is permitted to remain within current draw limitations. Often referred to as holdback valves, crankcase pressure regulators or suction pressure regulators, they also serve many other useful applications.

A downstream pressure regulator can be direct acting such as an OPR valve. These are hermetically sealed, non-repairable outlet pressure regulators for use on low capacity systems.

Adjustable Range Table

Valve	Adjustable Range
EPRB(S)-12 thru -20	0 to 110 psig
IPR-6, -10	0 to 50 psig 30 to 100 psig 65 to 225 psig
OPR-6, -10	0 to 60 psig 50 to 130 psig 100 to 225 psig

Standard Voltage & Frequencies Table

Voltage	Cycles
24	50-60 Hz, AC
120	
208-240	

Series EPRB & IPR

These are all upstream regulators which can be selected from the capacity charts available. Combining the regulator with a suction stop or shutoff solenoid will cause the regulator to act as a suction stop valve. Certain basic design operating condition data must be determined to properly apply the regulator. For best results, follow the simple procedure outlined below.

To select the proper regulator port size, the following information is required:

1. System refrigerant (R134a, R22, R404A/R507A).
2. The required pressure setting (lowest allowable evaporator pressure and corresponding refrigerant saturation temperature).
3. The system suction pressure at the regulator outlet (suction pressure where compressor capacity balances with system load) making allowance for any common suction line pressure drop.
4. Pressure drop across regulator port. Subtract suction pressure (3) from regulator set point (2).
5. Evaporator load in tons at regulator setting (required minimum evaporator saturation temperature).

With the above information, select the proper regulator as follows:

1. Select the valve extended capacity table from that page which covers the system refrigerant.
2. Find the required evaporator saturation temperature column.
3. For the available regulator pressure drop, find the rated capacity for each regulator port size.
4. Select the proper port size from the capacity which matches the evaporator load.

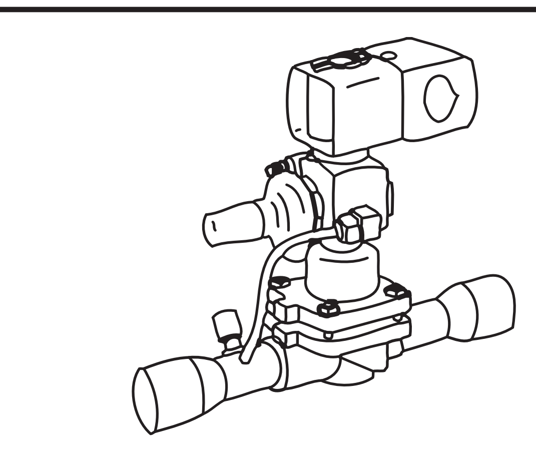


Figure 3: EPRB(S) Brass Body
Upstream Pressure Regulator with Suction Stop Option

Crankcase Regulators

Normally open, the CPR (Fig. 4) closes when compressor pressure rises above the pre-set maximum, forcing the valve back onto its seat. As suction pressure drops, the valve starts to reopen, maintaining a balance.

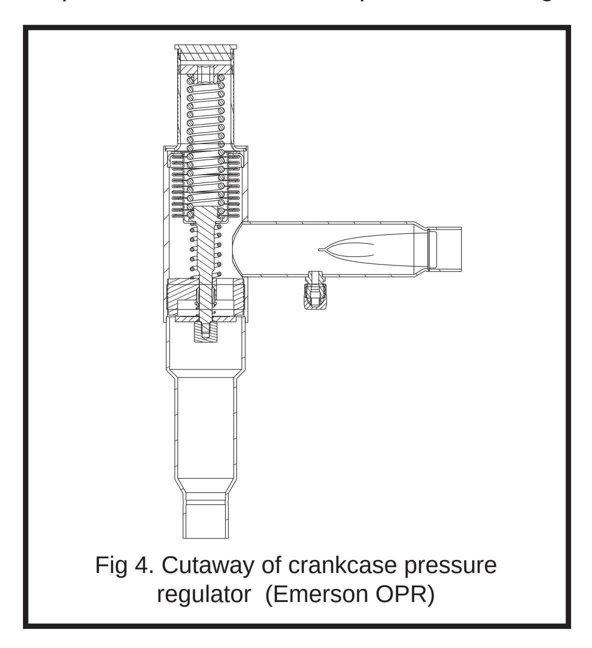


Fig 4. Cutaway of crankcase pressure regulator (Emerson OPR)

How to Apply Regulators

It isn't normally necessary to apply both an EPR and a crankcase regulator. Most installations only utilize an EPR.

Typical installations of EPRs are in supermarket systems, large chillers, and industrial processes where large amounts of heat must be absorbed. Smaller (including residential) systems of less than 5 tons are usually equipped with compressors designed to operate well within 30°-40°F variations.

One of the advantages of suction line regulators in supermarkets is that by adding EPRs you can control the operating temperatures of the individual cases in a single loop system.

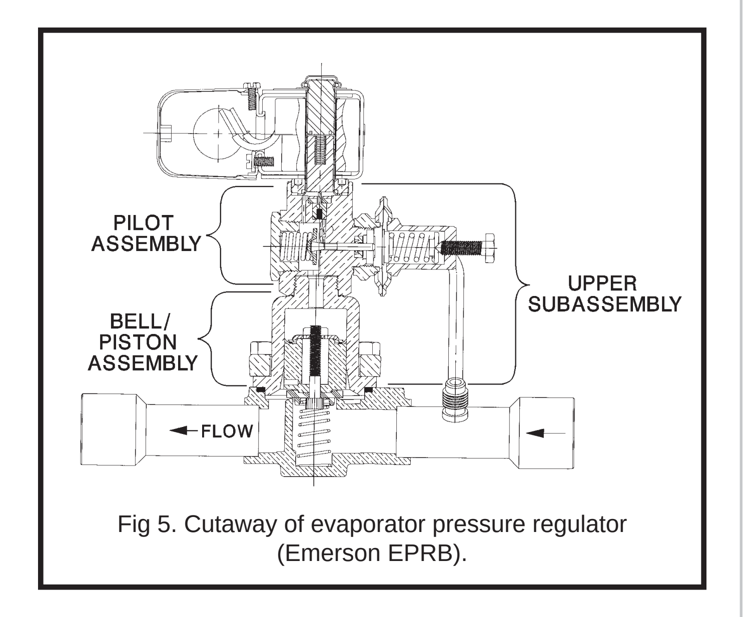


Fig 5. Cutaway of evaporator pressure regulator (Emerson EPRB).

Where to Apply Regulators

EPRs are most commonly used on multiple evaporator systems, installed in the branch lines close to the required control source. They are used for indirect temperature control. They also maintain evaporator pressure during defrost, conserving power, expediting the defrost and reducing flood back.

CPRs are usually only applied if the system is being continually "over-pressured," causing the compressor to be overloaded. If you suspect that's the case, check the amp draw on the compressor while it's running. If it's higher than the plate rating, the system may be a CPR candidate.

HeadMaster Head Pressure Controls

The application of air-cooled condensers for year-round operation, or during periods of low ambient temperature, requires some means of control to maintain adequate condensing pressures that ensure proper system performance. It is essential that proper liquid refrigerant pressure be controlled to:

1) Maintain liquid subcooling and prevent liquid line flash gas.
2) Provide adequate pressure at the inlet side of the Thermostatic Expansion Valve to get enough pressure drop across the valve port.
3) Properly operate systems with hot gas defrost or hot gas bypass.
4) Provide adequate temperature for operation of heat reclaim systems.

Without proper control of condensing pressure a refrigeration system might not perform properly and components can be damaged. Emerson's HeadMaster Control offers an efficient and economical approach to this common industry problem on air cooled condensers.

The HeadMaster 3-Way Head Pressure Control eliminates the need for special piping or multiple control valves. As a single unit it simplifies piping and cuts installation costs.

HeadMaster HP Operation

The HP control is a three-way modulating valve controlled by the discharge pressure. The charged dome exerts a constant pressure on top of the diaphragm. At high ambient air temperature, bypass gas entering Port B is allowed under the diaphragm where it counters the pressure of the dome charge. This upward push on the diaphragm allows the seat disc to seal against the top seat, preventing flow from Port B (discharge gas) while flow from Port C is unrestricted (see figure 6).

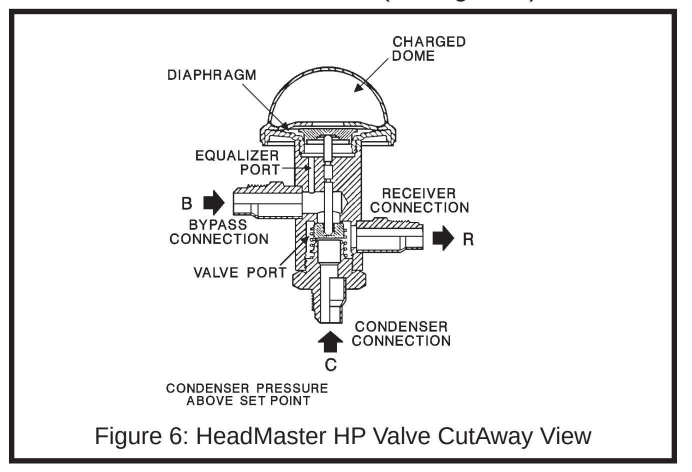


Figure 6: HeadMaster HP Valve CutAway View

As ambient air temperature falls, an uncontrolled air cooled condenser will exhibit a corresponding decrease in head pressure. As the discharge (bypass) pressure falls, it no longer counters the dome charge pressure and the diaphragm moves downward, moving the push-rod and seat disc toward the bottom seat. This allows discharge (bypass) gas to be metered into the receiver, creating a higher pressure at the condenser outlet. The higher pressure at the condenser outlet reduces the flow from Port C and causes the level of condensed liquid to rise in the condenser.

The flooding of the condenser with liquid cuts the available condensing surface. The result is to raise the pressure in the condenser and maintain an adequate high side pressure. Figure 7 illustrates a typical application of the 3-way control valve. This system is perhaps the most economical and reliable way to control discharge pressure. The three-way valve as shown in figure 6 is a fixed, non-adjustable valve. The wholesaler replacement setting is normally furnished for a pressure corresponding to 95° to 98°F condensing temperature for the given system refrigerant.

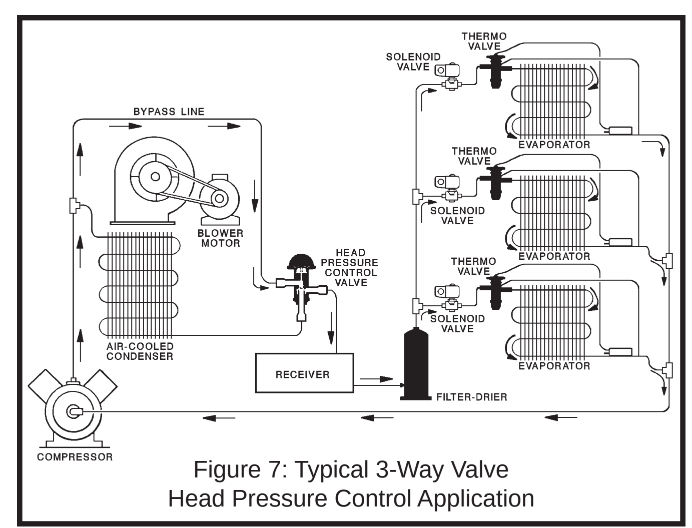


Figure 7: Typical 3-Way Valve Head Pressure Control Application

As with all head pressure control applications, additional liquid receiver capacity is required to prevent loss of a liquid seal in the receiver when the condenser is flooded. The receiver must be large enough to hold the total system charge. The total system charge consists of the following:

1. An operating charge which is the amount of refrigerant needed to operate the system during summer (high ambient temperature) conditions.
2. An additional charge equaling the amount of refrigerant required to flood the condenser with liquid. The condenser must be filled with liquid to a point where a minimum head pressure is created for cold weather (low ambient temperature) conditions.

NOTE: Should the outdoor temperature fall below design conditions, more refrigerant will be required.

The total above is the total charge needed for satisfactory system performance during the lowest expected ambient air temperature conditions. During summer operation the receiver must be sized to safely hold the total system charge. Good refrigeration practice states that the total system charge should not exceed 80% of the receiver capacity.

CAUTION:

1. The HP control should not be used on a system which does not have a liquid receiver or on one with a receiver which is too small. If the receiver does not have adequate storage space, the refrigerant will back up in the condenser to produce excessively high discharge pressures during high ambient air temperatures, with could cause system damage or personal injury.
2. The HP control should be used only on systems which employ a Thermostatic Expansion Valve.

Installation of HP HeadMaster Series

Head pressure control systems are used on refrigeration systems that are temperature operated. The compressor is started by a thermostat or the system operates on a pump down cycle, where the thermostat controls the liquid line solenoid valve and the compressor starts on a rise in suction pressure with a low pressure switch.

On systems that are pressure operated, migration of the refrigerant to the cold condenser on the "off" cycle should be prevented. If the system does not operate on a pump down cycle, migration can take place through some compressors, from the suction line to the condenser. Crankcase heaters will prevent liquid from condensing in the crankcase, but will not stop migration to the cold condenser. If the system is properly charged, the filled condenser will permit the excess to remain in the receiver and low side.

Under some conditions where the receiver is located in a warm ambient, a check valve in the liquid drain line between the HeadMaster control and the receiver may be required to prevent the liquid receiver pressure from equalizing to that of the condenser during the "off" cycle. This enables the system to start on a pressure switch. Some systems may require a time delay on the low pressure switch. Condenser fans should not be cycled when using the HeadMaster control. The sudden changes in high side pressure caused by fan cycling will result in erratic Thermostatic Expansion Valve performance, and shortened head pressure control life. To prevent this from happening, make sure fan controls are set to operate at pressures above the HP valve setting.

HP Series Capacity & Selection

The nominal HP control capacity in tons for various refrigerants is shown in Table 1 for R134a, R22 and R404A/R507A. The nominal capacity is based on 100°F liquid, 40°F evaporator and the pressure drop shown. To get capacities in tons at other liquid and evaporator conditions, multiply the nominal capacity at the desired pressure drop by the correction factor given in the catalog for the liquid temperature and evaporator temperature.

Table 1 – Nominal Capacity (tons)

Valve	Refrigerant	Pressure Drop – PSI				
		1	2	3	4	5
HP-5	R-134a	2.0	2.9	3.6	4.1	4.6
HP-8		5.5	7.8	9.6	11.0	12.4
HP-14		14.0	19.8	24.2	28.3	31.7
HP-5	R-22	2.2	3.2	3.9	4.5	5.0
HP-8		6.0	8.5	10.5	12.0	13.5
HP-14		14.7	20.8	25.6	29.7	33.8
HP-5	R-404A R-507A	1.5	2.1	2.6	3.0	3.3
HP-8		3.9	5.5	6.7	7.8	8.7
HP-14		10.1	14.3	17.6	20.5	23.0
Based on 100°F liquid and 40°F evaporator						

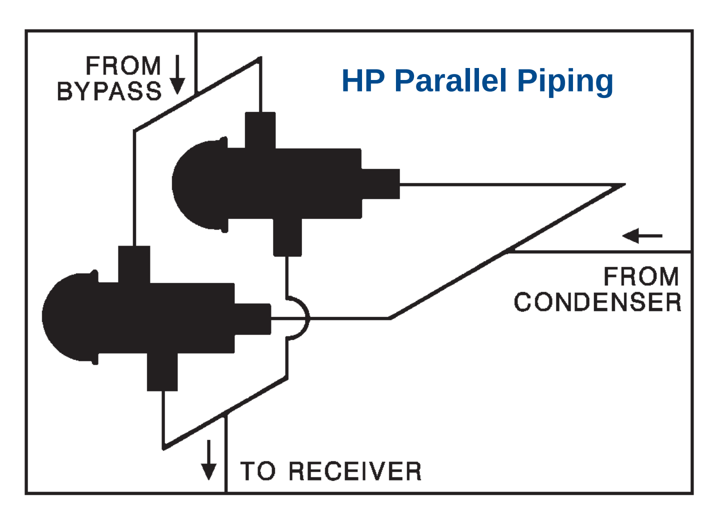
NOTE: Not recommended for systems utilizing patented subcooling coils in conjunction with low head pressure systems or on sytems where the condensate line bypassses the receiver in order to maintain subcooling effect in the liquid line.

NOTE: Do not select a valve for a capacity rating exceeding 5 psi pressure drop from Port C to Port B or for a system with more than 20 psi pressure drop across the condenser.

During normal ambient conditions, the available liquid subcooling in the condenser will be adequate to cover the pressure drop through the HeadMaster control.

If a valve is selected for a given flow rate, the resulting pressure drop must not cause the liquid pressure to drop below saturation and produce flash gas. If enough sub-cooling is not available to cover this pressure drop, it is suggested that more than one valve be installed in parallel to lower the pressure drop to tolerable limits.

Do not parallel valves of different capacities. Liquid drain lines from the condenser to receiver are sized for a velocity of 150 ft./min. or less.



Additional Refrigerant

On most systems, an added refrigerant charge will be required. It is essential to have enough to completely fill the condenser for the lowest ambient condition. To accurately determine the added refrigerant charge required to fill the condenser, find the total length of condenser tubing in feet, and multiply by pounds of refrigerant per foot for a given size tubing.

Factory Settings

The HeadMaster Control is factory-set to provide an average condensing temperature consistent with good system performance. The complete type number includes the service reference code, port size, connection size and style. When ordering, be sure to specify the complete type number.

UL File No. SA5312
CSA File No. LR44005

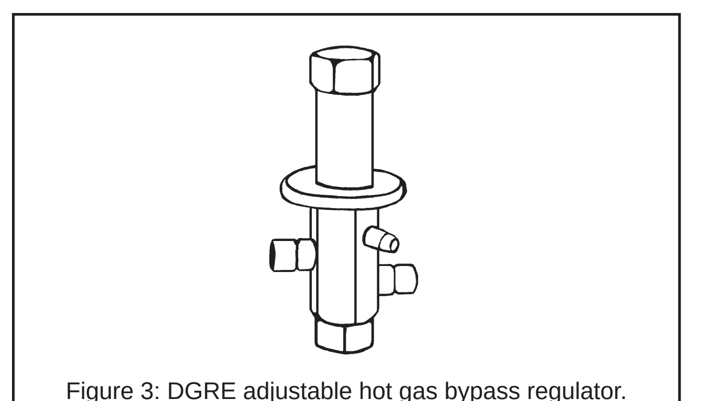


Figure 3: DGRE adjustable hot gas bypass regulator.

Hot Gas Bypass

Demand continues to mount for improved comfort conditioning combined with lower operating costs. New architectural designs have created real problems for contractors and engineers to maintain humidity control at reduced loads, and to control load variations. Refrigeration and air conditioning systems are usually designed to provide a given capacity at maximum conditions. These operate with little fluctuation throughout a narrow load range. However, only the larger size machines make any provisions for operation at reduced capacity. In some systems, integral cylinder unloading, gas engine drives with variable speed control, or even several smaller systems, provide a logical solution.

Function – Hot Gas Bypass Method

Many manufacturers now recommend use of a modulating control valve to provide a metered flow of compressor discharge gas to the system low side, in a proportion that will balance the system capacity to the load demand. This is commonly known as the hot gas bypass method. It permits full modulation of capacity on all types of reciprocating compressors, and extends capacity reduction below the last step of cylinder unloading.

The system must provide a means of bypassing high pressure refrigerant to the system low pressure side, to maintain operation at a given minimum suction pressure. Proper bypass control can be accomplished by a modulating type pressure regulator, which opens on a decrease in valve outlet pressure.

Operation of Bypass Valves

Bypass pressure regulators are grouped into the following categories:

1. Direct acting conventional port valves (figure 3)
2. Direct acting balanced port valves (figure 4). Any of these regulators are available with either an adjustable setting, or a fixed, non adjustable setting.

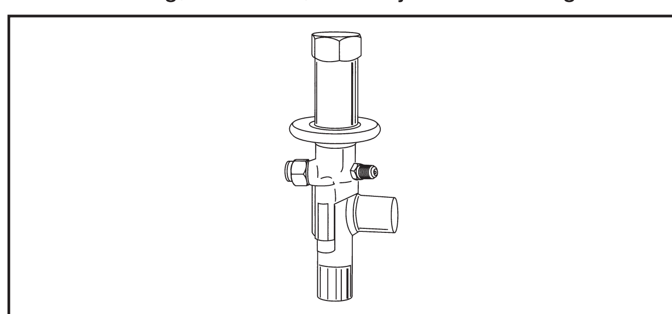


Figure 4: Balance port CPHE adjustable field-serviceable hot gas bypass regulator.

Applications: Hot Gas Bypass to Compressor Suction Line

Figure 6 shows the most common hot gas bypass system. In this system, the bypass line is taken directly from the compressor discharge line, through a bypass regulator, and into the suction line at the compressor. Although the hot gas bypass regulator is considered a downstream control, there is a big difference in function between a Crankcase Regulator and a hot gas regulator.

Pilot operated bypass valve main regulators have a long stroke stem with a restrictor plug characterized by either a parabolic or vee port restrictor plug design. This prevents the valve from operating close to the seat where pressure differential unbalance may occur, eliminating the need for a balanced port design.

The characterized port will provide smooth bypass flow modulation. Pilot operated valves usually have the extra features of a manual opening stem for testing or emergency operation, flanged connections, synthetic tight seating seats, and replaceable parts. Hot gas bypass valves can be applied to a system in several ways, differing only in the point to which the hot gas is to be bypassed. Several mixing methods are available. The one recommended is piped so that discharge gas is admitted to the suction line to flow against the direction of the suction gas as in figure 6.

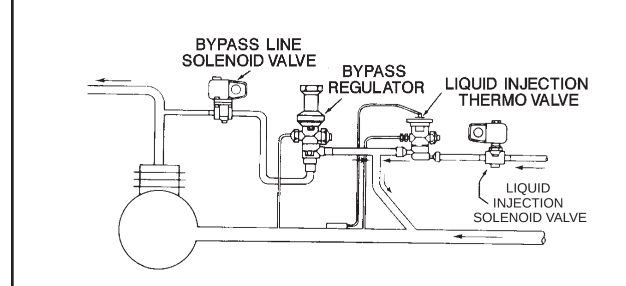


Figure 6: Hot gas bypass using type LCL liquid injection valve.

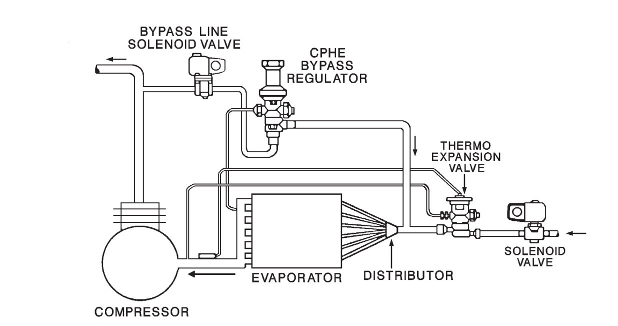


Figure 7: Direct acting hot gas regulator admitting flow between TEV and venturi distributor.

Applications: Bypass to Evaporator Inlet

Another method is to bypass the hot discharge gas to the evaporator inlet, usually between the Thermal Valve and the refrigerant distributor (see figure 7). This provides distinct advantages. The artificial load imposed on the evaporator causes the Thermal Valve to respond to the rise in superheat, eliminating the need for the liquid injection valve. The evaporator serves as an excellent chamber to provide homogeneous mixing of the gases before reaching the compressor.

Hot gas bypass into the evaporator is suggested when the evaporator elevation is below the compressor, to prevent oil trapping caused by low velocity at low loads. This assures proper oil return. Although there are many advantages to this system, it is not used on a multiple coil system, or where the evaporator sections may be located a distance from the compressor. The coil should be a free draining circuiting design to prevent the increase in velocity, due to forcing a large quantity of trapped liquid out of the low side, which in some cases may have enough volume to flood the compressor crankcase. Separate regulators must be used for each evaporator when bypassing to multiple evaporators located below the compressor to help oil return.

Bypass to flooded evaporators and suction line accumulators also present special cases. Contact the equipment manufacturer or the bypass control valve manufacturer for specific, detailed information.

Solenoid Valve for Positive Shut-off & Pump-down Cycle

It is recommended that a solenoid valve be installed ahead of the bypass regulator. This permits the system to operate on an automatic pump-down cycle.

Thermal Valves for Liquid Injection

When hot gas is bypassed directly into the suction line, it is necessary to make some provision for desuperheating the gas returning to the compressor. Without a small Thermal valve to lower suction gas temperature to tolerable limits, compressor damage may occur. Standard Thermal Valves cannot be adjusted for control over 20°F superheat and, therefore, are not recommended. Liquid Injection Thermal Valves with special adjustment ranges are used to conform to compressor manufacturer temperature recommendations.

To simplify selection, Emerson has developed Liquid Injection Thermal Valves with four basic adjustment ranges. These are designated as models A, B, C and D. The adjustable superheat range chart (page 11) shows the proper power assembly charge symbol suffix for a given saturated suction temperature and a given superheated suction gas temperature entering the compressor.

Nearly all Thermal valves for liquid injection may be internally equalized. However, if pressure drop occurs at the valve outlet due to a distributor, spray nozzle or other restrictive device, externally equalized valves may be needed.

Model LER and LIR valves are furnished with a 1/4" SAE male flare external equalizer as standard. Other models must include the code letter "E" to specify the 1/4" SAE male flare external equalizer connection. Example: LCLE and LJLE.

Application and Installation

Liquid injected into a gas to be desuperheated should be injected in a way which provides a homogeneous mixing of the liquid and superheated gas. Desuperheating hot gas bypass in the suction line may be accomplished in several ways.

The preferred method is to bullhead the hot gas and liquid injection in a tee to permit good mixing before it enters the suction line. A good mix with the suction gas may be gained by injecting the liquid/hot gas mixture into the suction line at a 45° angle against the flow of suction gas to the compressor. See figure 6.

For suction lines 7/8" OD and smaller, the bypass mixture may be introduced into a tee rather than an angle connection. For lines larger than 2-5/8" OD, introduce the desuperheated bypass mixture into a 90° ell inserted against the flow of suction gas to the compressor.

Arranging a bypass directly into a suction accumulator is often a convenient way to get proper desuperheating of suction gas.

Introducing the hot gas and liquid into the suction line with separate connections is not recommended.

NOTE: Excessive suction gas superheat can cause serious damage to the compressor. As a safety precaution, the bypass line solenoid valve should be wired in series with a discharge line thermostat.

Special Applications

On systems where evaporator pressure regulators are used, better control can be reached by installing the bypass regulator equalizer line on the downstream (outlet) side of the EPR so it responds to compressor suction pressure, not evaporator pressure. This results in nearly constant evaporator load balance. See figure 8.

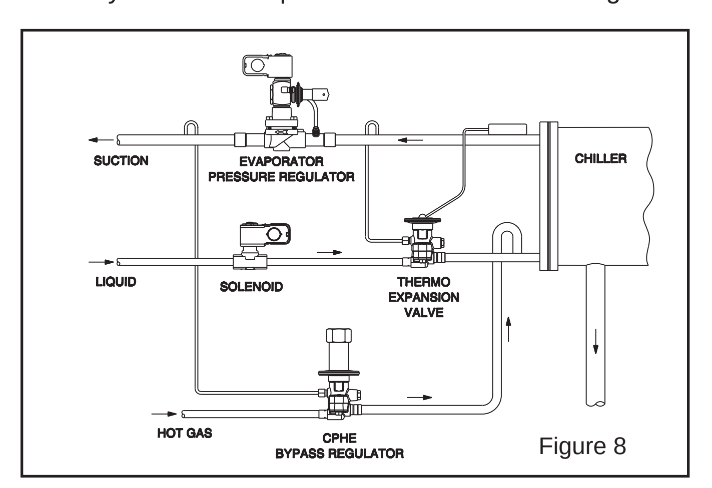


Figure 8

Adjusting the Set Point

The suction pressure at which the valve opens is selectable by increasing or decreasing the load on the spring by turning an adjusting screw. To set it, the evaporator must be cooled down by shutting off the fans, blocking off the airflow, or some other means, until the suction pressure drops to at least five pounds below the desired set point. Then, by allowing the pressure to be raised by the bypass gas, the spring load can be varied until the valve closes at precisely the desired set point.

The pressure is set to maintain an evaporator temperature just above that at which frost forms.

Application Tips

- In systems that use a Venturi type distributor, the bypass gas should be fed into the system between the outlet of the expansion valve and the inlet to the distributor. For pressure drop distributors that use an orifice, the inlet must be between the orifice and the inlet to the distributor.
- The hot gas bypass line should be insulated to minimize system heat loss.
- In systems with sequential compressor unloading, the valve should be set to start opening at two to three pounds below the last stage of unloading, because compressor unloading is considerably more efficient and should be used before resorting to bypassing.
- For oil return considerations, the bypass line must feed in ahead of the evaporator when the evaporator is installed below the compressor.
- The hot gas bypass valve should be installed as close as practical to the condensing unit, to reduce condensing ahead of it.
- In systems that operate on a pump down cycle, there must be a solenoid valve or some other means of shutoff in the bypass line.

Oil Controls

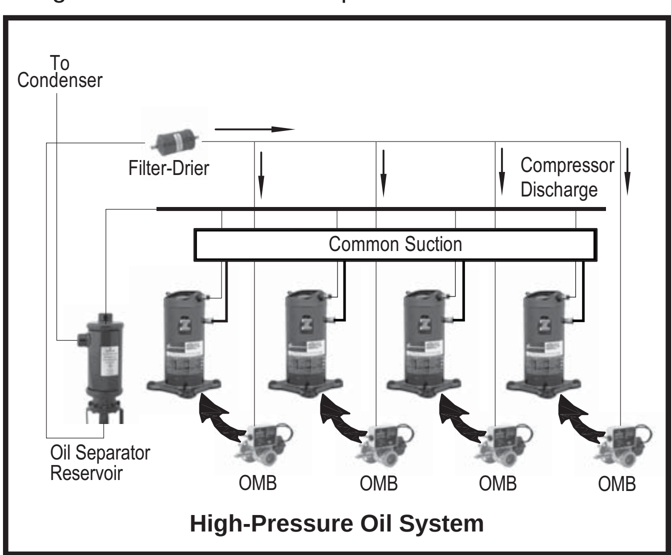


Oil Controls

Any time that compressors are operated in a parallel operation (Suction and Discharge lines manifolded together), an oil control system in needed to ensure that each compressor has enough oil to operate properly.

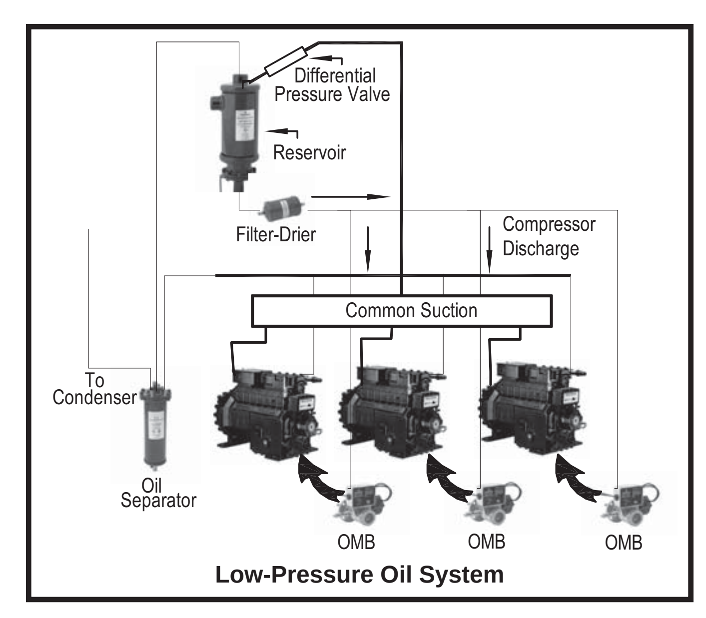
Oil control systems are sometimes as basic as a common line connected between compressors to allow oil and gas equalization. This is usually referred to as a "passive" oil system. Although this may suffice on two-compressor systems, compressor racks of three or more compressors almost always have an "active" system since even small differences in crankcase pressures can cause oil starving. This system uses an oil separator to capture most of the oil from the compressor discharge gas since some oil is carried out of the compressor with the refrigerant. Several types of oil separators are commonly used in these applications. The older style is called an impingement type while newer, more efficient types are the centrifugal and coalescing types.

After the oil is separated from the refrigerant, it collects in the bottom of the oil separator where it is fed directly to the crankcase in a high-pressure oil system using oil controls on the compressor crankcases.



High-Pressure Oil System

A low-pressure oil system incorporates a separate oil reservoir which is downstream of the separator. Oil separators in low-pressure oil systems have a float valve in the bottom to allow excess oil to pass to the reservoir whenever the level is high enough in the separator to open the valve. The pressure in the oil reservoir is usually held 20-30 psi above the crankcase pressure through a differential check valve. This lower pressure allows mechanical oil floats, which use a float valve which opens when the crankcase oil level falls below 1/sight glass, to be used to feed oil into the compressor crankcases. The mechanical floats cannot be used on high-pressure oil systems because the oil pressure entering them would be too high and cause them to not be able to control the oil level.

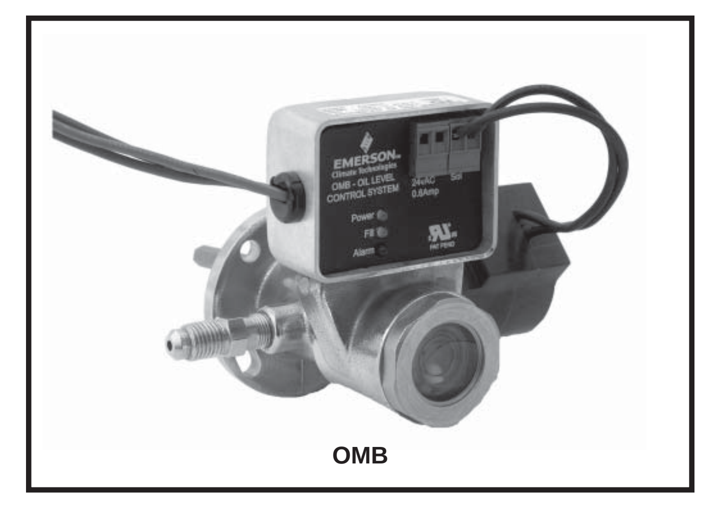


Low-Pressure Oil System

On all oil systems, it is important to install an oil filter downstream of the oil separator to ensure a supply of clean oil to the compressors.

Emerson Oil Controls

A high-pressure oil system can use an Emerson OMB oil control mounted on the compressor crankcase. The OMB is a device which uses a reverse Hall-effect magnetic float to activate a solenoid to allow oil to flow into the crankcase whenever the level falls below 1/2sight glass level. It is designed to operate at oil pressures up to 350 psid.



OMB

Temperature Pressure Controls



Temperature Pressure Controls

Temperature pressure controls serve a number of purposes in refrigeration systems, including the control of compressor cycling, pump-down, defrost control, pressure limiting, loss of charge freeze protection and fan speed control.

TS1 Introduction

The TS1 Series is Emerson's adjustable thermostats for application in refrigeration and heat pump systems. In these systems, thermostats provide space temperature control, high/low temperature alarming or defrost termination. By operating an electrical contact, a temperature value is kept inside a certain limit.

Housing Variants

TS1 controls are top operated. Top operated controls have adjustment spindles at the top and a display scale, showing temperature setpoint and differential, at the front. A knob which may be permanently plugged onto one of the adjustment spindles comes with every control. Frost monitors and room thermostats are derivatives of top operated thermostats. They differ by their sensors and other features to suit their target applications.

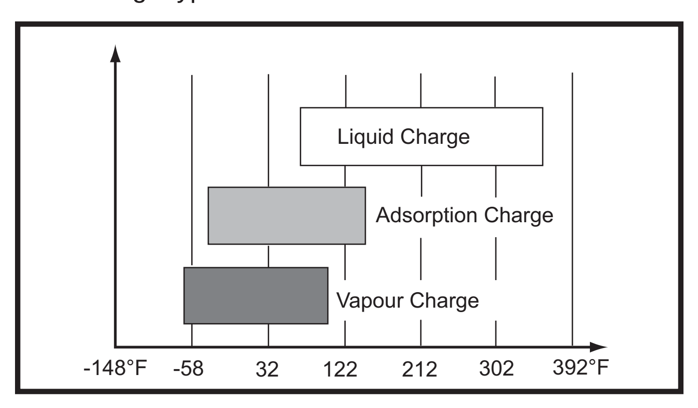


TS1 Top Operated

Temperature Sensing

TS1 thermostats sense temperature by a thermal system, consisting of temperature charge, bulb, capillary and bellows. The temperature charge changes its pressure based on the refrigerant temperature to be sensed. The sensor is the part of the system which is in thermal contact with the refrigerant. The capillary connects the sensor with the bellows and the bellows contracts or expands depending on the temperature, causing the thermostat to operate the electrical contacts. An exception are capillary type of sensors, which do not have a bulb, instead, their capillary serves as the bulb directly.

Charges and sensor types are matched to temperature ranges and other application specific characteristics. TS1 thermostats come with one of three charge types: vapor charges, adsorption charges or liquid charges. The application temperature range covered by each charge type is shown below:



Vapor Charge – Sensor Type A, E, P

These sensing elements always sense from the coldest point on the capillary, coil, bulb or power element head. For proper operation, the coldest point must be at the part of the sensor which is exposed to the medium temperature to be sensed. The sensing location should be at least 4 degrees F colder than the other parts of the thermal system.

To avoid unwanted effects of heat transfer, for example from a cold wall, vapor charged thermostats come with an integrated bellows heater (not for frost monitors), which is rated for 230V applications. For other applications, the heater must be disabled or a bellows heater with a different rating should be used.

Besides the bellows heater, room thermostats are supplied with an insulation console for the same reason.

Sensor type 'A' is a coiled bulb sensor with two meter capillary, which may be used with or without a bulb well. Style 'E' is a coil sensor for space temperature sensing, and type 'P' is a capillary type of sensor which can be wrapped around a heat exchanger's surface to sense the coldest point on the heat exchanger for frost protection applications.

Vapor charges respond faster to temperature changes than adsorption and liquid charges.

Adsorption Charge – Sensor Type F

Adsorption charged sensor types operate on a temperature dependent adsorption material, which is inside the bulb only. These sensor types always respond to temperature changes at the bulb only. This makes them suitable to applications where it is not always defined which part of the thermal system the coldest point is (cross ambient applications). An example for such applications is defrost control.

Adsorption charges are slower in response to temperature changes than vapor charges.

Liquid Charge – Sensor Type C

Liquid charge sensors of type ‘C’ always sense from the warmest point of the thermal system. The sensing location must always be 4 degrees F warmer than other parts of the thermal system.

Setpoints

TS1 are adjustable controls with adjustment spindles for range and differential. Note that manual reset controls and some other controls have a fixed differential and no differential spindle. By turning the range spindle, the upper setpoint is defined and by adjusting the differential spindle, the differential and the lower setpoint is defined.

The dependency between upper and lower setpoint is always as follows:

lower setpoint = upper setpoint – differential

The following two rules should be kept in mind:

⇨ an adjustment of the range spindle always affects both upper and lower setpoint.

⇨ an adjustment of the differential spindle affects the lower setpoint only.

The controls are equipped with display scale and pointers to show the approximate settings.

Top operated controls have display scales in units °C and °F, front operated controls have a display scale in units °C.

For precise setting of the controls, external thermometers must be used.

Electrical Contacts

TS1 temperature controls are equipped with high rated double snap action contacts for shatter-free and reliable operation.

All contacts in these controls are designed as Single Pole Double Throw (SPDT) contacts. One contact may be used for control and the other contact for alarm/status indication or auxiliary control.

Gold plated contacts are available on request for low electrical loads, for example in electronic signaling applications.

For applications using a supply voltage other than 230V and for applications using gold plated contacts, the bellows heater of vapor charged thermostats (sensor style A, E or P – not for frost monitors function C or D) must be disabled.

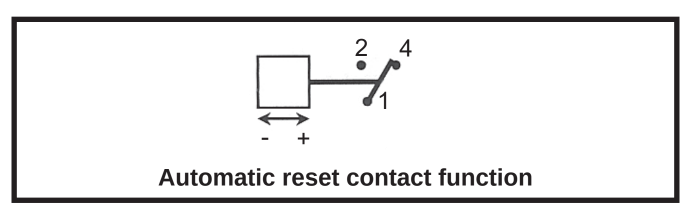
Contact Function

Thermostat contacts TS1 are labeled 1-2-4 where ‘1’ refers to the common pole, ‘2’ refers to the lower setpoint and ‘4’ refers to the upper setpoint.

The contact function for automatic and manual reset versions is as described below.

Automatic Reset

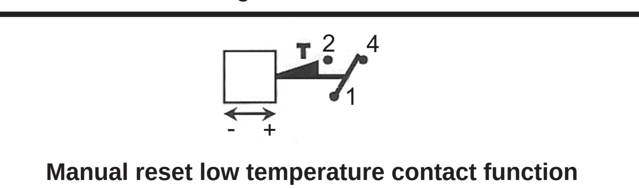
On temperature rise above the upper setpoint, contacts 1-open and contacts 4 close. On decreasing temperature lower setpoint contacts 4 open and contacts close.



Automatic reset contact function

Manual Reset Low Temperature

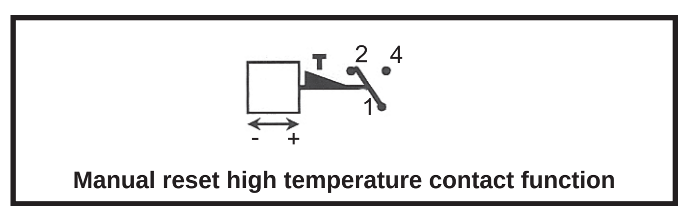
On decreasing temperature below the lower setpoint, contacts 1-4 open, contacts close and latch. Only on temperature rise above upper setpoint and after pressing the manual reset button contacts will open and contacts 4 will close again.



Manual reset low temperature contact function

Manual Reset High Temperature

On increasing temperature above the upper setpoint, contacts 1-open, contacts 4 close and latch. Only on falling temperature below lower setpoint and after pressing the manual reset button, contacts 4 will open and contacts 1-will close again.

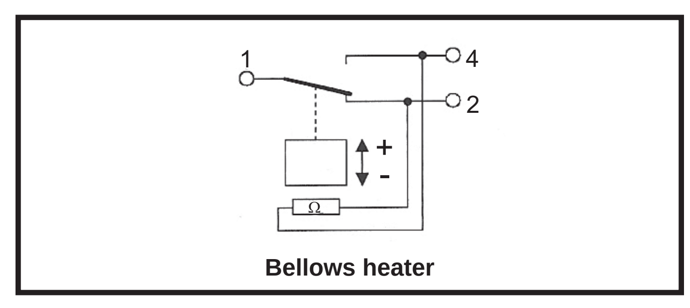


Manual reset high temperature contact function

For operational safety, all TS1 with manual reset are designed as trip-free controls, i.e. pressing the manual reset button while the temperature has not reached its reset threshold will not operate the electrical contacts.

Bellows Heater

TS1 with vapor charges, i.e. sensor types A, E, P (not frost monitors function C or D) have a bellows heater wired across the contacts in the following way.



Bellows heater

PS1/PS2 Introduction

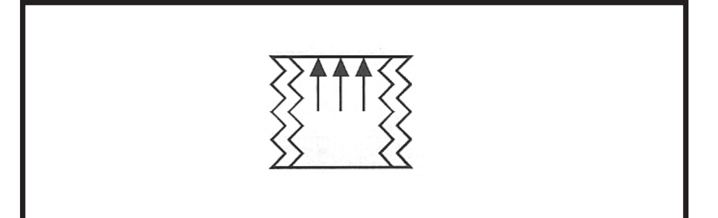
The PS1/PS2 Series is Emerson's adjustable pressostats for application in refrigeration and heat pump systems.

In these systems, pressure controls serve control and protection functions. Examples of control are compressor cycling, pump-down or defrost control. Protection includes pressure limiting and cut out against excessive pressures, against loss of charge or for freeze protection.

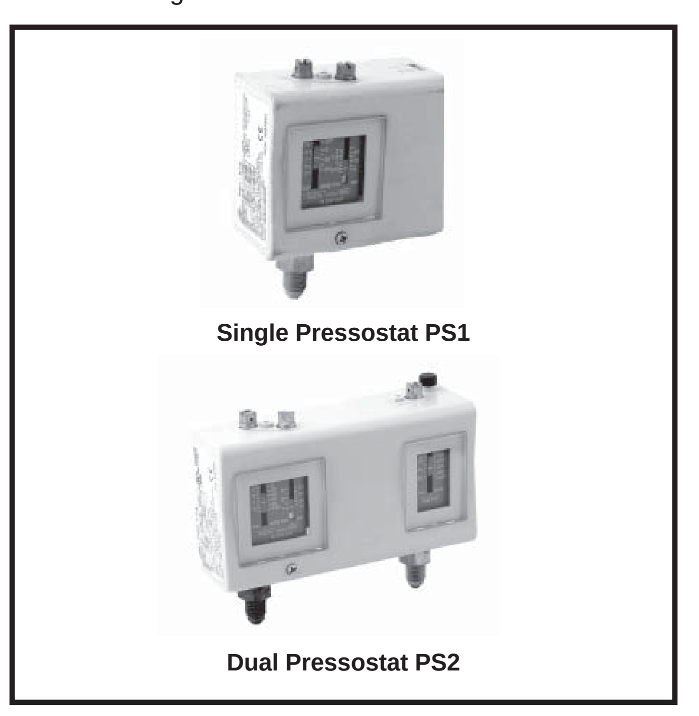
Pressure Sensing

All pressures mentioned in this document are understood as gauge pressures. PS1/PS2 controls sense pressure by bellows which expand or contract when exposed to medium pressure.

High pressure limiters and pressure cut outs with type approval according to EN 12263 feature a double bellows design. The inner bellows serves as the operating bellows and is enclosed by the outer bellows featuring a larger surface area.



Should the inner bellows leak, then the larger surface area of the outer bellows creates a larger force and causes the pressostat to a pre-empted cut out. This represents a fail-safe function. Standard controls for refrigeration applications are equipped with a bronze bellows and can be used with all common HFC, HCFC and CFC refrigerants.



Single Pressostat PS1

Dual Pressostat PS2

Pressure Connectors

A variety of pressure connectors, including male and female flare type connectors, capillary and solder connectors are available. The standard connector is a 7-16”-20 UNF male flare connector, which, in its high pressure versions, is equipped with a snubber to protect against pressure pulsations.

Electrical Contacts

PS1/PS2 pressure controls are equipped with high rated double snap action contacts for shatter-free and reliable operation.

All contacts in these controls are designed as Single Pole Double Throw (SPDT) contacts. One contact may be used for control and the other contact for alarm/status indication or auxiliary control. Dual Pressostats PS2 come with two independently actuated SPDT contacts, providing for even further application flexibility by allowing for a variety of wiring options.

Setpoints

PS1/PS2 are adjustable controls with external adjustment spindles for range and differential. Note that manual reset controls have a fixed differential and no differential spindle. By turning the range spindle, the upper setpoint is defined and by adjusting the differential spindle, the differential and the lower setpoint is defined.

The dependency between upper and lower setpoint is always as follows:

lower setpoint = upper setpoint – differential

The following two rules should be kept in mind:

⇨ an adjustment of the range spindle always affects both upper and lower setpoint.

⇨ an adjustment of the differential spindle affects the lower setpoint, only.

The controls are equipped with display scale and pointers to show the approximate settings. The display scales are printed in relative pressure units “bar” and “psi”. For precise setting of the controls, external gauges must be used.

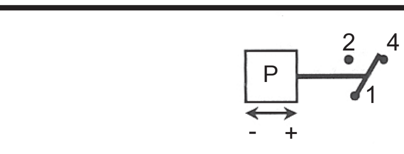
Contact Function

Contacts on Single Pressostats, PS1 are labeled 1-2-4 where ‘1’ refers to the common pole, ‘2’ refers to the lower setpoint and ‘4’ refers to the upper setpoint. This is true for all types of controls, irrespective whether they are low pressure controls, high pressure controls, manual or automatic reset types.

The contact function for automatic and manual reset versions is as described below.

Automatic Reset

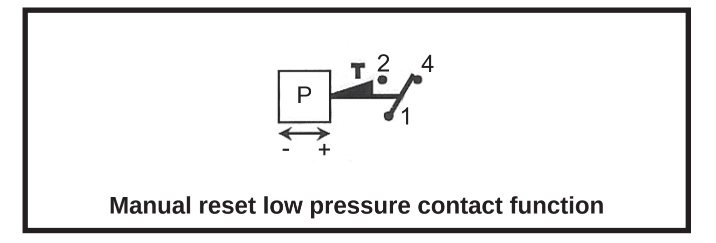
When pressure rises above the upper setpoint, contacts 1-2 open and contacts 1-4 close. On decreasing temperature lower setpoint contacts 1-4 open and contacts 1-2 close.



Automatic reset contact function

Manual Reset Low Pressure

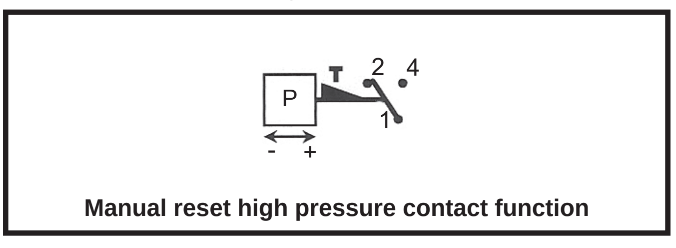
When pressure drops below the lower setpoint, contacts 1-4 open, contacts 1-2 close and latch. Only on pressure rise above upper setpoint and after pressing the manual reset button contacts 1-2 will open and contacts 1-4 will close again.



Manual reset low pressure contact function

Manual Reset High Pressure

When pressure rises above the upper setpoint, contacts 1-2 open, contacts 1-4 close and latch. Only on falling pressure below lower setpoint and after pressing the manual reset button, contacts 1-4 will open and contacts 1-2 will close again.



Manual reset high pressure contact function

For operational safety, all PS1/PS2 with manual reset are designed as trip-free controls, i.e. pressing the manual reset button while the pressure has not reached its reset threshold will not operate the electrical contacts.

As Dual Pressostats PS2 have two sets of contacts, their function is the same as on Single Pressostats PS1 with the only difference that the contact labels are preceded by an additional index. One side of the control is labeled 11-12-14 and the second side is 21-22-24.

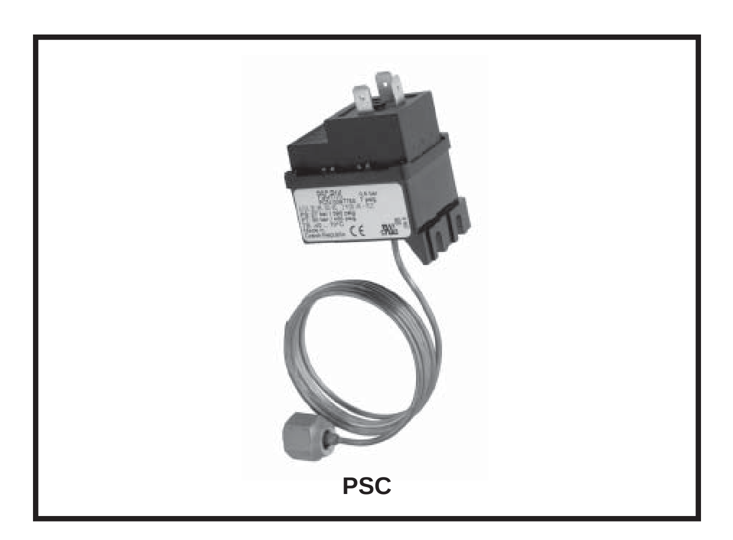
The contact function of controls with convertible reset is as described above but depends on the position of the convertible reset toggle, i.e. automatic or manual reset position.

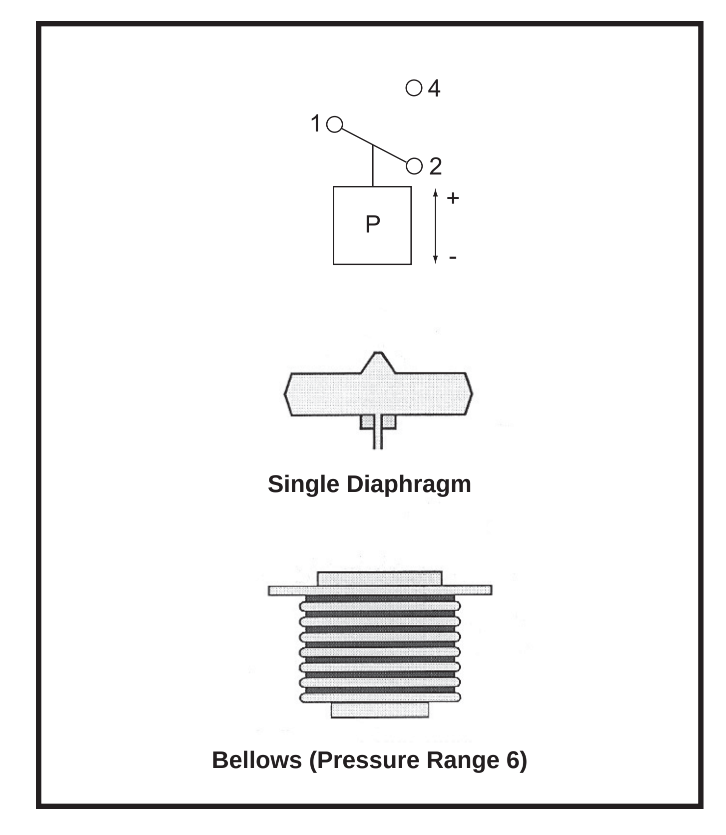
PSC Pressure Switch

The Emerson PSC is a Pressure Switch with fixed switch-point settings.

Features
- Maximum Operating Pressure up to 623 psig Test Pressure up to 696 psig
- Standard factory settings from stock in small volumes
- High and low pressure switches
- High temperature version with snubber for direct compressor mounting (Range 6)
- Direct mounting reduces the number of joints and thus avoiding potential leakage
- Precise setting and repeatability
- IP 65 protection if used with the cables with plug

Options
- For direct mounting on a pressure connection (free standing) or with a capillary tube
- Direct compressor head mounting with high temperature bellows and snubber
  - reduces the number of joints
  - avoids potential leakage
  - saves high cost of flexible hose
- TÜV approved versions for high and low pressure
- Micro-switch for narrow pressure differentials
- Gold plated contacts for low voltage/current applications
- Cables with plug ordered separately


PSC



Single Diaphragm

Bellows (Pressure Range 6)

PSC Introduction

PSC is equipped with a SPDT snap action contact, switching from 1-2 to 1-4 on rising pressure and from 4 to on falling pressure (see diagram). Several models are available:

- Low pressure switch, with automatic or manual reset
- High pressure switch, with automatic or manual reset
- DIN/TÜV approved safety high pressure limiter with automatic reset
- DIN/TÜV approved safety high pressure cut-out, with internal or external manual reset

TÜV approval for pressure switches can be reached either by using a double diaphragm (Pressure range 1-5) which acts in a fail-safe mode or by a single pressure element (Bellows, Pressure range 6) which is able to resist to >Mio. cycles between 50% and 100% of the maximum operating pressure (see 4.6.1 of EN 12263).

FSX Introduction

FSX electronic speed controllers are designed to control the speed of fan motors in commercial refrigeration system depending on condensing pressure changes. It is suitable for single phase. FSX can be used in air-cooled condensers, air-cooled condensing units and air-conditioning units.

Using variable fan speed controllers offers the following benefits in commercial refrigeration or air-conditioning applications:

• Head pressure can be kept high enough to ensure proper operation of the expansion valve, and sufficient mass flow through the expansion valve to feed the evaporator. This maintains the required cooling capacity.
• Efficiency increase of the compressor by controlling the head pressure, improved performance and energy saving for the complete system.
• The noise of the motor can be kept at a minimum by avoiding permanent on/off cycling.



FSX-43S

Description of control behavior

FSX control behavior can be easily described by looking at the function of output voltage versus input pressure (see figure 1) and by dividing it into maximum, proportional and minimum range.

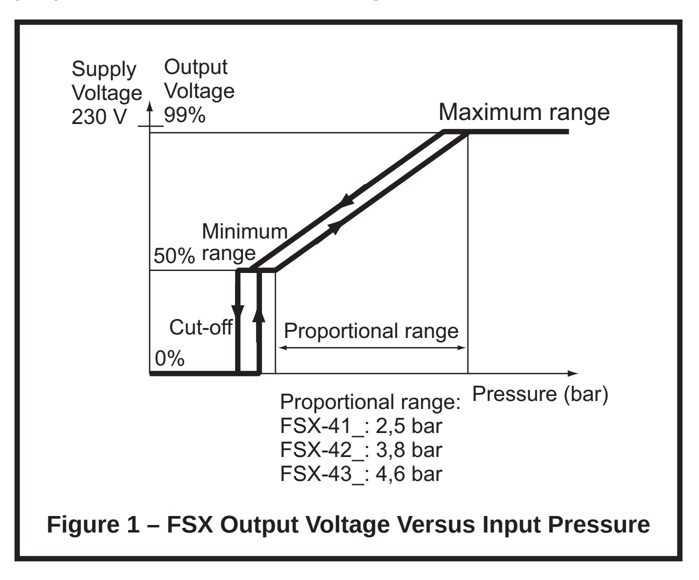


Figure 1 – FSX Output Voltage Versus Input Pressure

In the maximum range, the FSX provides a constant output voltage of about 1% below the supply voltage. The fan runs at maximum speed.

Along the proportional range the output voltage varies between maximum and minimum voltage of approximately 50% of the supply voltage. This causes the fan speed to slow down from maximum speed to minimum speed.

Further decrease of pressure in the minimum range leads to cut-off of the fan motor. Increase of input pressure will start the motor with a hysteresis of approximately 10 psig to avoid cycling (Fig. 1).

The pressure from which motor is cut off (FSX), see column “pressure range” in the selection chart. The proportional range is fixed at:

36 psig for FSX-41_/FSM-41_
55 psig for FSX-42_/FSM-42_
66 psig for FSX-43_/FSM-43_

Basic Rules of Good Practice



Basic Rules of Good Practice

Doing a good job in any line of work almost always involves following some basic "good practice" rules, and servicing refrigeration systems is no exception. Knowing and observing such basic rules, to the point that it becomes automatic, can prevent a lot of problems by cutting them off at the pass before they have a chance to happen.

A list of DO's, procedures that should be followed, and a list of DON'Ts representing pitfalls that should be avoided are presented here to promote the general adoption of good servicing practices and a better understanding of the WHYs behind them. An occasional quick review may serve to reinforce awareness and help make their application second nature.

DOs

***DO* maintain test instruments in good working order and periodically check them against accurately calibrated instruments.**

Good diagnoses can't be made with faulty inputs.



***DO* familiarize yourself with the operation of a control before attempting to make adjustments or repairs.**

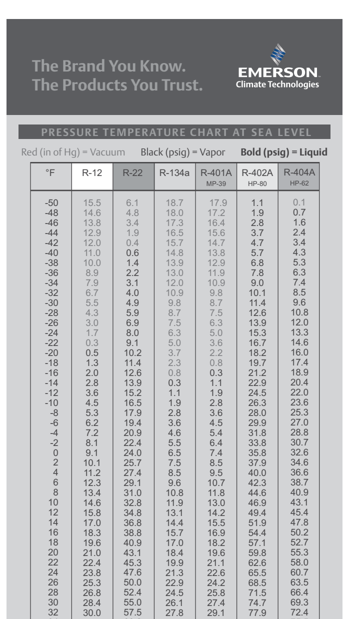
If you don't understand how a control is supposed to function, you can't be sure if it's defective or not. When you know what you're doing, you achieve good results on purpose; when you don't know what you're doing, you achieve good results only by accident.

***DO* make it a practice to check suction gas superheat at the compressor.**

Too low superheat may result in liquid flood-back, while high superheats cause high discharge temperatures. Always follow equipment manufacturers' instructions.

***DO* replace filter driers or replaceable cartridges whenever it's necessary to open a system for service.**

Regardless of how careful you are, it's virtually impossible to prevent the entry of moisture and other contaminants while the system is open. Driers or cartridges cannot be successfully activated in the field for reuse. A new filter drier or cartridge is cheap insurance for a compressor.



PRESSURE TEMPERATURE CHART AT SEA LEVEL

Red (in of Hg) = Vacuum Black (psig) = Vapor **Bold (psig) = Liquid**

°F	R-12	R-22	R-134a	R-401A MP-39	R-402A HP-80	R-404A HP-62
-50	15.5	6.1	18.7	17.9	1.1	0.1
-48	14.6	4.8	18.0	17.2	1.9	0.7
-46	13.8	3.4	17.3	16.4	2.8	1.6
-44	12.9	1.9	16.5	15.6	3.7	2.4
-42	12.0	0.4	15.7	14.7	4.7	3.4
-40	11.0	0.6	14.8	13.8	5.7	4.3
-38	10.0	1.4	13.9	12.9	6.8	5.3
-36	8.9	2.2	13.0	11.9	7.8	6.3
-34	7.9	3.1	12.0	10.9	9.0	7.4
-32	6.7	4.0	10.9	9.8	10.1	8.5
-30	5.5	4.9	9.8	8.7	11.4	9.6
-28	4.3	5.9	8.7	7.5	12.6	10.8
-26	3.0	6.9	7.5	6.3	13.9	12.0
-24	1.7	8.0	6.3	5.0	15.3	13.3
-22	0.3	9.1	5.0	3.6	16.7	14.6
-20	0.5	10.2	3.7	2.2	18.2	16.0
-18	1.3	11.4	2.3	0.8	19.7	17.4
-16	2.0	12.6	0.8	0.3	21.2	18.9
-14	2.8	13.9	0.3	1.1	22.9	20.4
-12	3.6	15.2	1.1	1.9	24.5	22.0
-10	4.5	16.5	1.9	2.8	26.3	23.6
-8	5.3	17.9	2.8	3.6	28.0	25.3
-6	6.2	19.4	3.6	4.5	29.9	27.0
-4	7.2	20.9	4.6	5.4	31.8	28.8
-2	8.1	22.4	5.5	6.4	33.8	30.7
0	9.1	24.0	6.5	7.4	35.8	32.6
2	10.1	25.7	7.5	8.5	37.9	34.6
4	11.2	27.4	8.5	9.5	40.0	36.6
6	12.3	29.1	9.6	10.7	42.3	38.7
8	13.4	31.0	10.8	11.8	44.6	40.9
10	14.6	32.8	11.9	13.0	46.9	43.1
12	15.8	34.8	13.1	14.2	49.4	45.4
14	17.0	36.8	14.4	15.5	51.9	47.8
16	18.3	38.8	15.7	16.9	54.4	50.2
18	19.6	40.9	17.0	18.2	57.1	52.7
20	21.0	43.1	18.4	19.6	59.8	55.3
22	22.4	45.3	19.9	21.1	62.6	58.0
24	23.8	47.6	21.3	22.6	65.5	60.7
26	25.3	50.0	22.9	24.2	68.5	63.5
28	26.8	52.4	24.5	25.8	71.5	66.4
30	28.4	55.0	26.1	27.4	74.7	69.3
32	30.0	57.5	27.8	29.1	77.9	72.4
34	31.6	60.2	29.5	30.9	81.2	75.5
36	33.3	62.9	31.3	32.7	84.6	78.7

***DO* use an accurate moisture indicator in the liquid line to watch out for moisture contamination.**

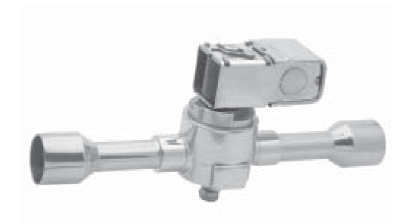
It is the single most common contaminant, and it can lead to a variety of problems including acid, sludge, and freeze-ups.

***DO* check expansion valve superheat by using the temperature-pressure method.**

This involves measuring the suction line pressure at the evaporator outlet and then referring to the appropriate temperature-pressure chart to determine the saturation temperature. Subtracting this temperature from the suction line temperature measured at the remote bulb gives you the operating superheat, which should be adjusted to the equipment manufacturer's specifications.

DON'Ts





DON'T be a "parts-changer."

Analyze problems based on the symptoms, and determine the specific cause before making any changes or repairs. Emerson's Troubleshooting Guide describes a wide variety of problems that may be encountered, and their probable causes.

DON'T think of a TXV as a temperature or pressure control.

Thinking of it as a superheat control is basic to achieving optimum system performance.

DON'T attempt to use any control for any application other than the one it was designed for.

Using a pressure regulator for a pressure relief valve, or any similar substitution, is not good practice and almost certainly won't deliver proper performance. Misapplications can lead to equipment damage and even injury. When doubt exists, check with the manufacturer.

DON'T energize a solenoid coil while it is removed from the valve.

Without the magnetic effect of the solenoid core, the coil will burn out in a matter of seconds.

DON'T install a previously used filter drier or replaceable cartridge.

It could introduce contaminants that it has picked up since its removal from a system.

DON'T select solenoid valves by line size or port size, but by valve capacity.

They must also be compatible with the intended application with regard to the specific refrigerant used, the maximum opening pressure differential (MOPD), the maximum working pressure (MWP), and the electrical characteristics. Never apply a valve outside of its design limits or for uses not specifically catalogued.

DON'T rely on sight or touch for temperature measurements.

Use an accurate thermometer. Once again, you can't get accurate diagnoses with faulty inputs.

Troubleshooting Guide



2009

SYSTEM TROUBLESHOOTING GUIDE

System Problem	Discharge Pressure	Suction Pressure	Superheat	Subcooling	Amps
Overcharge	↑	↑	↓	↑	↑
Undercharge	↓	↓	↑	↓	↓
Liquid Restriction (Drier)	↓	↓	↑	↑	↓
Low Evaporator Airflow	↓	↓	↓	↑	↓
Dirty Condenser	↑	↑	↑	↑	↑
Low Outside Ambient Temperature	↓	↓	↓	↑	↓
Inefficient Compressor	↓	↑	↑	↑	↓
TXV Bulb Loose Mounted	↑	↑	↓	↓	↑
TXV Bulb Lost Charge	↓	↓	↑	↑	↓
Poorly Insulated Bulb	↑	↑	↓	↓	↑

Troubleshooting Expansion Valves

Superheat Is Too Low -- TXV Feeds Too Much

Problem	Symptoms	Causes	Corrective Action
Valve Feeds Too Much	1) Liquid Slugging 2) Low Superheat 3) Suction Pressure Normal or High	Oversized Valve	Replace with correct size valve
		Incorrect Superheat Setting	Adjust the superheat to correct setting
		Moisture	Replace the filter-driers; evacuate the system and replace the refrigerant
		Dirt or Foreign Material	Clean out the material or replace the valve
		Incorrect Charge Selection	Select proper charge based on refrigerant type
		Incorrect Bulb Location	Relocate the bulb to proper location
		Incorrect Equalizer Location	Relocate the equalizer to proper location
		Plugged Equalizer (Balanced Port Valve)	Remove any restriction in the equalizer tube

Superheat Is Too High -- TXV Doesn't Feed or Doesn't Feed Enough

Problem	Symptoms	Causes	Corrective Action
Valve Doesn't Feed or Doesn't Feed Enough	1) Evaporator Temperature Too High 2) High Superheat 3) Low Suction Pressure	Short of Refrigerant	Add correct amount of refrigerant
		High Superheat	Change superheat setting
		Flash Gas In Liquid Line	Remove source of restriction
		Low or Lost Bulb Charge	Replace power element or valve
		Moisture	Replace driers or evacuate the system and replace refrigerant
		Plugged Equalizer (Conventional Valve)	Remove restriction in equalizer tube
		Insufficient Pressure Drop or Valve Too Small	Replace existing valve with properly sized valve
		Dirt or Foreign Material	Clean out material or replace valve
		Incorrect Charge Selection	Select correct charge
		Incorrect Bulb Location	Move bulb to correct location
		Incorrect Equalizer Location	Move equalizer to correct location
		Charge Migration (MOP Only, Vapor Charges)	Move valve to a warmer location or apply heat tape to powerhead
		Wax	Use charcoal drier
		Wrong equalizer Type Valve	Use externally equalized valve
		Rod Leakage (Balanced Port Valve)	Replace valve
		Heat Damaged Powerhead	Replace powerhead or valve

No Superheat At Start Up Only

Problem	Symptoms	Causes	Corrective Action
Valve Feeds Too Much At Start Up	1) Liquid Slugging 2) Zero Superheat 3) Suction Pressure Too High	Refrigerant Drainage	Use pump down control; Install trap at the top of the evaporator
		Compressor or Suction Line in a Cold Location	Install crankcase heater; Install suction solenoid
		Partially Restricted or Plugged External Equalizer (Balanced Port Valve)	Remove restriction
		Liquid Line Solenoid Won't Shut	Replace powerhead or valve

Superheat Is Erratic Or Hunts

Problem	Symptoms	Causes	Corrective Action
System Hunts or Cycles	1) Suction Pressure Hunts 2) Superheat Hunts 3) Erratic Valve Feeding	Bulb Location Incorrect	Reposition Bulb
		Valve Too Large	Replace with correctly sized valve
		Incorrect Superheat Setting	Adjust superheat to correct setting
		System Design	Redesign system

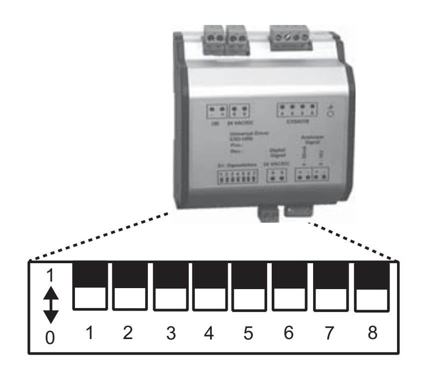
Superheat Appears Normal -- System Performs Poorly			
Problem	**Symptoms**	**Causes**	**Corrective Action**
Valve Doesn't Feed Properly	1) Poor System Performance 2) Low or Normal Superheat 3) Low Suction Pressure	Unequal Circuit Loading	Make modification to balance load
		Flow From One Coil Affecting Another Coil	Correct piping
		Low Load	Correct conditions causing low load
		Mismatched Coil/Compressor	Correct match
		Incorrect Distributor	Install correct distributor
		Evaporator Oil-Logged	Increase gas velocity through coil

Troubleshooting Electronic Valves & Controls

EXD-U00 TROUBLESHOOTING – (Driver with Auxillary Controller)

Symptom	Possible Cause	Action	Remark
Valve is not moving	Digital input has priority to analogue signal input	Digital input must be activated and deactivated along with compressor start and stop	
	Wrong setting of dipswitches	Adjust the dip switches correctly. The power supply must be off during this action	
	Supply voltage too low		Supply voltage: 24VAC ± 10% if external ECP-024 is used. Supply voltage: 24VAC or VDC ± 10% if external ECP-024 is not connected
	Wrong wiring between valve and driver	Correct the wiring	
Valve operating in reverse direction	Wrong wiring between driver and valve	Correct the wiring	
The valve is not at the position corresponding to input signal	Digital input of driver has been jumpered so there is no synchronization at all		
Driver does not show any life	Wrong supply voltage applied	Change EXDU00	Temporary high voltage such as 110V/230V may damage the driver

Function	Dip Switch Number							
	1	2	3	4	5	6	7	8
EX4/EX5/EX6 operation	0	1	1	0	1	0	–	–
EX7 operation	1	0	0	1	0	1	–	–
EX8 operation	1	1	0	1	1	1	–	–
4-20 mA analogue input signal	–	–	–	–	–	–	–	0
0-10V analogue input signal	–	–	–	–	–	–	–	1
With start mode	–	–	–	–	–	–	1	–
Without start mode	–	–	–	–	–	–	0	–



EC3-X33 TROUBLESHOOTING – (Controller with Keypad)

Symptom	Cause	Action
Superheat is several degrees higher or lower than set-point	Incorrect signal from pressure or temperature sensors	1. Check the sensors 2. Make sure ECN-Nxx temperature sensor is used 3. For optimum accuracy, please use: PT4-07S for R22/R134a/R507/R404A/R407C/R124 PT4-18S for R410A or for economizer applications PT4-30S for R744 4. Make sure the sensor cables are not installed along with other high voltage cables (keep minimum 1.5 inch away)
Superheat is too low i.e. compressor wet running	1. Incorrect wiring of ECVs 2. Defective sensors	1. Check the wiring 2. Check the sensor
Valve is not fully closing	1. The digital input is ON (24V) 2. Wrong setting of parameter ut	1. Valve is shut off only when the digital input is turned off (0V) 2. Check the setting of parameter ut
Instable superheat (hunting)	Uneven refrigerant distribution or evaporator with very long length/ time constant Evaporator is designed to operate at higher superheat	Change superheat control mode from standard to slow Increase the superheat set-point
Valve opens when EC3 commands to close and vice versa	Wrong wiring between EC3-X33 and valve	Correct the wiring
EX8 is not able to open at high differential pressure	Wrong setting of parameter ut	Check the parameter ut. (Larger valve requires higher torque and higher current)
Superheat set-point is shifting after several months of uninterrupted operation or permanent jumper of 24V digital input	Stepper motor driven valves require synchronization	Do not apply permanent 24V digital input. Interrupt digital input once every week for 5 seconds if compressor never stops
ECD-002 display unit does not show any information	No connection or improper connection between ECD-002 and EC3-X33 Wrong electrical plug EC3-X33 is defective	Use only CAT 5 LAN cable Use RJ45 only (RJ11 is not suitable) Change the EC3-X33
EC3-X33 does not show any life	Wrong supply voltage applied	Change EC3-X33
EC3-X33 internal stepper motor chip is burn out	Short circuit of output terminals (for connection to ECV) or short circuit between output terminal with ground	Change EC3-X33

EC3-X33 TROUBLESHOOTING – (Controller with Computer)

Symptom	Cause	Action
Superheat is several degrees higher or lower than set-point	Incorrect signal from pressure or temperature sensors	1. Check the sensors 2. Make sure ECN-Nxx temperature sensor is used 3. For optimum accuracy, please use: PT4-07S for R22/R134a/R507/R404A/R407C/R124 PT4-18S for R410A or for economizer applications PT4-30S for R744 4. Make sure the sensor cables are not installed along with other high voltage cables (keep minimum 1.5 inch away)
Superheat is too low i.e. compressor wet running	1. Incorrect wiring of ECVs 2. Defective sensors	1. Check the wiring 2. Check the sensor
Valve is not fully closing	1. The digital input is ON (24V) 2. Wrong setting of parameter ut	1. Valve is shut off only when the digital input is turned off (0V) 2. Check the setting of parameter ut
Instable superheat (hunting)	Uneven refrigerant distribution or evaporator with very long length/ time constant Evaporator is designed to operate at higher superheat	Change superheat control mode from standard to slow Increase the superheat set-point
Valve opens when EC3 commands to close and vice versa	Wrong wiring between EC3-X32 and valve	Correct the wiring
EX8 is not able to open at high differential pressure	Wrong setting of parameter ut	Check the parameter ut. (Larger valve requires higher torque and higher current)
Superheat set-point is shifting after several months of uninterrupted operation or permanent jumper of 24V digital input	Stepper motor driven valves require synchronization	Do not apply permanent 24V digital input. Interrupt digital input once every week for 5 seconds if compressor never stops
Not able to get data on PC monitor	No connection or improper connection between PC and EC3-X32 Wrong electrical plug EC3-X32 and PC are not in a logical network	Check the network wiring Use RJ45 only (RJ11 is not suitable) Check TCP/IP configuration of Windows(2000, XP or Vista)
EC3-X32 does not show any life	Wrong supply voltage applied	Change EC3-X32
EC3-X32 internal stepper motor chip is burn out	Short circuit of output terminals (for connection to ECV) or short circuit between output terminal with ground	Change EC3-X32

Troubleshooting Solenoid Valves

Problem	Causes	Corrective Action
Normally Closed Valve Will Not Open -or- Normally Open Valve Will Not Close	Movement of plunger or diaphragm restricted a) Corroded parts b) Foreign material lodged in valve c) Dented or bent enclosing tube d) Warped or distorted body due to improper brazing or crushing in vice	Clean affected parts and replace parts as required. Correct the cause of corrosion or source of foreign materials in the system.
	Improper wiring	Check electrical circuit for loose or broken connections. Attach voltmeter to coil leads and check voltage, inrush and holding currents
	Faulty contacts on relays or thermostats	Check contacts in relays and thermostats. clean or replace as required.
	Voltage and frequency rating or solenoid coil not matched to electrical supply: a) low voltage b) high voltage c) incorrect frequency	Check voltage and frequency stamped on coil assembly to make certain it matches electrical source. If it does not, obtain new coil assembly with proper voltage and frequency rating: a) Locate cause of voltage drop and correct. Install proper transformer, wire size as needed. Be sure all connections are tight and that relays function properly. b) Excessively high voltage will cause coil burnout. Obtain new coil assembly with proper voltage rating. c) Obtain new coil assembly with proper frequency rating.
	Oversized Valve	Install correct sized valve. Consult extended capacities tables.
	Valve improperly assembled.	Assemble parts in proper position making certain none are missing from valve assembly.
	Coil Burnout a) Supply voltage at coil too low (below 85% of rated coil voltage) b) Supply voltage at valve too high (more than 10% above coil voltage rating) c) Valve located at high ambient d) Plunger restricted due to: corroded parts, foreign materials lodged in valve, dented or bent enclosing tube or warped or distorted body due to improper brazing or curshing in vise e) With valve closed, pressure difference across valve is too high preventing valve from opening f) Improper wiring. Inrush voltage drop causing plunger to fail to pull magnetic field due to: - Wiring the valve to the load side of the motor starter - Wiring the valve in parallel with another appliance with high inrush current draw - Poor connetions, especially on low voltage, where connections should be soldered - Wire size of electrical supply too small g) Electrical supply (voltage and frequency) not matched to solenoid coil rating	a) Locate cause of low voltage and correct (check transformer, wire size, and control rating) b) Locate cause of high voltage and correct (install proper transformer or service) c) Ventilate the area from high ambient. Remove covering from coil housing d) Clean affected parts and replace as required. Connect cause of corrosion or source of foreign material in the system e) Reduce pressure differential to less than 300psi f) Correct wiring according to valve manufacturers' instructions. Solder all low voltage connections. Use correct wire size. g) Check coil voltage and frequency to ensure match to electrical service rating. Install new coil with proper voltage and frequency rating.
Normally Closed Valve Will Not Close -or- Normally Open Valve Will Not Open	Diaphragm or plunger restricted due to: corroded parts, foreign material lodged in valve, dented or bent closing tube, or warped body due to improper brazing or crushing in vise	Clean affected parts and replace parts as required. Correct the cause of corrosion or source of foreign materials in the system. Install a filter-drier upstream of solenoid valve
	Manual opening stem holding valve open	With coil de-energized, turn manual stem in counter clockwise direction until valve closes
	Closing spring missing or inoperative	Re-assemble with spring in proper position
	Electrical feedback keeping coil energized, or switch contacts not breaking circuit to coil	Attach voltmeter at coil leads and check for feedack or closed circuit. Correct faulty contacts or wiring
	Reverse pressures (outlet pressure greater than inlet pressure), or valve installed backwards	Install check valve at valve outlet, or install with flow arrow in proper direction
Problem	**Causes**	**Corrective Action**
Valve Closes, But Flow Continues (Seat Leakage)	Foreign material lodged under seat	Clean internal parts and remove foreign material
	Valve seat damaged	Replace valve or affected parts
	Synthetic seat materials chipped	Replace valve or affected parts
	Valve improperly applied or assembled	Replace valve with proper valve or re-assemble

Special Considerations For Industrial Solenoid Valves		
Symptoms	**Causes**	**Corrective Action**
High Internal Seat Leakage (high temperature steam up to 400°)	Wrong Seat Elastomer Used (Buna N)	Use Valve with Teflon Seat Elastomer
External Leakage (high temperature steam up to 400°)	Wrong Gasket Material Used (Neoprene)	Use Ethylene Propylene Gasket
High Internal Seat Leakage (high temperature steam up to 250° or water up to 210°)	Wrong Seat Elastomer Used (Buna N)	Use Valve with Ethylene Propylene Seat Elastomer
External leakage (high temperature steam up to 250° or water up to 210°)	Wrong Gasket Material Used (Neoprene)	Use Ethylene Propylene Gasket

Troubleshooting Ball Valves

Symptoms	Causes	Corrective Action
Doesn't Flow	Valve Isn't Open	Turn Stem
Leak at Access Schrader Valve	Schrader Valve Isn't Tight	Tighten Schrader Valve
Leak at Stem	Valve Stem is Leaking	Replace Valve
Excessive Pressure Drop	Valve Isn't Fully Open	Turn Stem to Open Valve

Troubleshooting System Protectors

Allowable Pressure Drop -- Permanent Installation

Refrigerant	Evaporator Temperature				
	40°F	20°F	0°F	-20°F	-40°F
R12, R134a	2.0	1.5	1.0	0.5	-
R22, R410A	3.0	2.0	1.5	1.0	0.5
R502, R404A/507	3.0	2.0	1.5	1.0	0.5

Troubleshooting Storage Devices

Suction Line Accumulators

Problem	Causes	Corrective Action
Oil Not Returning to Compressor	Bleed Hole in U-Tube Plugged	Replace Accumulator; Install Filter Ahead of Accumulator
	U-Tube Broken Off	Replace Accumulator
	Accumulator Too Large for Application	Replace with Smaller Accumulator
	Accumulator Installed Incorrectly	Re-Install with Correct Inlet & Outlet Connections

Liquid Refrigerant Receivers

Problem	Causes	Corrective Action
Flashing In Liquid Sight Glass Downstream Of Receiver	Receiver Outlet Not Fully Open	Open Valve Fully
	On Receivers with Top Outlet Connections, the Dip Tube may be Broken Off Or Plugged	Replace Receiver
	Receiver Installed Upside Down	Re-Install Receiver Correctly

Troubleshooting Regulators

Problem	Causes	Corrective Action
Erratic Pressure Control	Pilot inlet filter screen obstructed	Clean or replace.
	Piston bleed hole restriction	Disassemble valve and clean. Replace if necessary.
Regulator Will Not Open (EPRBS Version)	Excessive dirt in pilot/solenoid	
	Piston bleed hole restriction	
	Coil is damaged or not energized	Verify coil is energized. Replace if necessary.
Excessive Pressure Drop Across the Regulator	Piston bleed partially obstructed	Disassemble and clean regulator.
	Pilot or solenoid leaking internally	Replace pilot assembly.
	Regulator undersized	Refer to extended capacities table. Install correct sized regulator.
Regulator Hunting (Fluctuations in Controlled Pressure)	Piston bleed port obstructed	Clean or replace.
	Pilot inlet filter screen obstructed	
	Regulator oversized	Refer to extended capacities table. Install correct sized regulator.
	Regulator and TXV have control interaction	Turn off pilot pressure. Ensure regulator is wide open. Adjust superheat to required setting. Turn pilot pressure back on.
	Regulator and cylinder unloaders have control interaction	The unloader should be set to control at least 5 psig lower than regulator.
Regulator Will Not Provide Pressure Control	Pilot inlet filter screen obstructed	Clean or replace.
	Pilot inlet pressure is too low	Increase pressure to a minimum of 25 psi higher than the main valve outlet pressure.
	Piston jammed due to excessive dirt; Inoperative pilot or broken diaphragm	Locate and remove the stoppage or dirt. Replace pilot. A broken diaphragm can be detected by checking for leaks around the adjusting stem.
Regulator Will Not Close (EPRBS Version)	Dirt under seat	Disassemble and clean.
	Excessive piston seal leakage	Replace bell piston assembly.
	Plugged pilot filter	Clean or replace.
	Pilot supply turned off or restricted	Verify pilot inlet pressure is at least 25 psig greater than valve outlet.
	Excessive dirt in pilot/solenoid	Replace pilot assembly.

Troubleshooting Hot Gas Regulators

Problem	Causes	Corrective Action
Low Suction Pressure - Valve Open	Valve undersized	Replace valve with correct size
Will Not Bypass - Valve Not Open	1. Solenoid (if present) not energized 2. Valve sticking closed 3. Not set properly 4. Bad pilot	1. Repair (replace solenoid coil) 2. Replace 3. Recalibrate 4. Replace
Suction Pressure Swings Erratically	Oversized valve	Replace valve with correct size
Bypass Continuously - Suction Pressure High	1. Manual stem screwed down 2. Valve sticking open 3. Bad pilot	1. Back stem out 2. Repair/replace valve 3. Replace pilot
Setpoint Drifts	Bad pilot	Replace pilot

Troubleshooting Crankcase Regulators

Problem	Causes	Corrective Action
Valve Won't Adjust or Is Erratic	Dirt under seat	With system running, open the valve adjustment to open the valve and flush away the contaminant. If this fails, replace valve.
Valve Throttles Constantly	On system equipped with Hot Gas Bypas Valves, the bypass valve setting is higher than CPR	Re-adjust bypass and/or CPR valve so that the CPR setting is higher than the discharge bypass valve
Temperature Pull-Down After Defrost is Too Long	TXV with MOP feature used with the CPR	To improve pull-down time, replace TXV with equivalent without MOP feature
	Valve setting is too low	Re-adjust the CPR to a higher setting - see adjustment procedure

Problem	Causes	Corrective Action
Compressor tripping on Internal Thermal Protector - Fails to Start-Up and Run Long Enough to Pull Down Temperature	CPR setting too high	Re-adjust the CPR to a lower setting - see adjustment procedure
Valve Fails to Open	CPR setting is too low	
	Valve defective - bellows leak, pressurizing the upper adjustment assembly	Replace valve

Troubleshooting Head Pressure Controls

Problem	Causes	Corrective Action
Low Head Pressure During Operation	Valve unable to throttle "C" port 1. Foreign material wedged between "C" port seat and seat disc 2. Power element lost its charge 3. Insufficient winter-time system charge	1. Artificially raise head pressure and tap valve body to dislodge foreign material 2. Change valve 3. Add refrigerant per Table 3
	Wrong charge pressure in valve for refrigerant	Change valve
	Receiver exposed to low ambient conditions is acting as condenser	Insulate the receiver
	Hot gas bypass line restricted or shut off	Clear obstruction or open valve
System Runs High Head Pressure -or- Cycles on High Pressure Cut-Out	Compressor not pumping, restriction in liquid line, low side causing very low suction pressure	Change or repair compressor; clear obstruction or other reason for low suction pressure
	Condenser fan not running or turning in wrong direction	Replace or repair fan motor, belts, wiring or controls as required
	Fan cycling	Run condenser fan continuously while system is running
	Pressure drop through condenser exceeds allowable 20 psi forcing "B" port partially open	Repipe, recircuit, or change condenser as required to reduce condenser pressure drop to less than 20 psi
	Condenser undersized or air flow restricted or short circuiting	Increase size of condenser or remove air flow restriction or short circuit as required
	"B" port wedged open due to foreign material between seat and seat disc	Artificially reduce head pressure below valve setpoint and tap valve body with system running to dislodge foreign material
	"B" port seat damaged due to foreign material	Change valve
	Wrong charge pressure in valve for refrigerant	
	Excessive system charge or air in system	Purge or bleed off refrigerant or non-condensables as system requires
	Obstruction or valve closed in discharge or condenser drain line	Clear obstruction or open valve
	Liquid line solenoid fails to open	Check solenoid

CHARGING THE SYSTEM - THEORETICAL METHOD

Weighing the Charge (Method has practical limitations)

Add refrigerant until the sight glass is clear and free of bubbles.

Determine refrigerant required to fill the condenser, see Table 3 below. Add this additional amount.

Table 3 - Refrigerant lbs. per ft.*

Refrigerant	Condenser Tube Size - O.D. (in inches)** and Ambient Temperature ° F											
	3/8"				1/2"				5/8"			
	40°	0°	-20°	-40°	40°	0°	-20°	-40°	40°	0°	-20°	-40°
R134a	.051	.054	.055	.057	.095	.099	.102	.105	.150	.157	.164	.167
R22	.051	.054	.055	.056	.094	.099	.102	.104	.150	.159	.163	.167
R404A/R507A	.053	.056	.058	.059	.098	.104	.107	.109	.157	.166	.171	.175

* Return bends: 3/8” O.D. - 20 ft; 1/2 O.D. - 25 ft.; 5/8 O.D. - 30 ft. (equivalent length of tubing/return bend)
** Wall thickness: 3/8” O.D. - .016”; 1/2 O.D. - .017”; 5/8 O.D. - .018”

Troubleshooting Oil Controls - OMB

Problem	Causes	Corrective Action
Oil Level Too High In Sight Glass	OMB out of calibration	Replace OMB
	Too much oil in system	Remove oil from oil separator or reservoir until proper level is maintained
	Too much oil coming back from evaporator	Check system piping design for: - Proper velocities - P-traps at the bottom of all suction risers - Piping pitched to compressor - Overlapping or defrosts that are not staggered
	Debris under solenoid valve seat	Unscrew solenoid valve, clean & replace
Problem	**Causes**	**Corrective Action**
Oil Level Too Low In Sight Glass	Oil separator or reservoir empty	Add oil to maintain a liquid seal in the bottom of the separator or reservoir
	Plugged oil line filter	Replace filter
	Plugged inlet strainer(s) on OMB	Remove and clean strainer on all affected OMB
	Solenoid coil defective	Replace coil
	Power loss to OMB	Check power to OMB. Green light should be lit.
Problem	**Causes**	**Corrective Action**
Foaming In Sight Glass	Liquid refrigerant in oil	Flood back through suction; Increase superheat on expansion valve; Refrigerant condensing in oil separator - add heater to oil separator and/or adjust system setting to eliminate flood back
	If so equipped, liquid injection overfeeding	Correct liquid injection overfeed
	Excess quantity of oil in crankcase	Remove excess oil
Problem	**Causes**	**Corrective Action**
Nuisance Oil Alarms	"Filling" light remains on even though level is 1/2 above sight glass	Replace OMB
	Alarm light on all the time	Replace OMB
	Intermittent oil return from system	Check system piping design for: - Proper veloicties - P-traps at the bottom of all suction risers - Piping pitched to compressor - Overlapping or defrosts that are not staggered

Troubleshooting Oil Separators

Problem	Causes	Corrective Action
Reduced or No Oil Feed to Compressor	Oil outlet valve closed or partially closed	Open oil outlet valve
	Inadequate oil charge in system	Add oil in system
	Oil float defective or dirty (will not open)	Disassemble and clean or replace defective float component (flanged versions); Replace oil separator (welded version).
	Separator too small for application	Replace separator with larger size
Hot Gas Entering Compressor	Oil float defective or dirty (will not close)	Disassemble and clean or replace defective float component (flanged versions); Replace oil separator (welded version).



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